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Ankylopterix sp., Semenyih, Selangor, Malaysia (forest)

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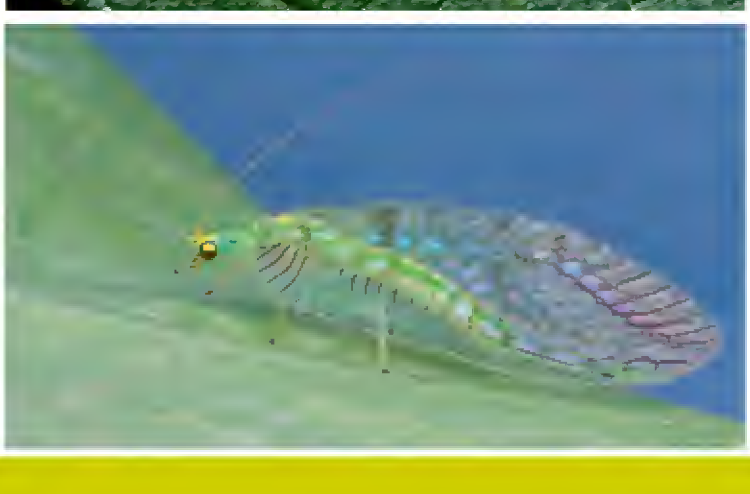

The genus *Ankylopteryx* Brauer, 1864 (Neuroptera Chrysopidae). In 1864, Brauer established the new genus *Ankylopteryx* for five species of green lacewings from Mozambique, India, China, Sumatra and Ceylon (i.e. Sri Lanka), furthermore he described three new ones from Nicobare Islands, Ambon Island (Moluccas), and Van Diemens Land (i.e. Tasmania), already reflecting the currently known distribution of the genus, which shows a continuous presence in the Palaeotropics from Africa (South of Sahara), Madagascar, Arabian Peninsula, Islands of Indian Ocean, India, South China, Ryukyu Islands, Indonesia, Australia, New Hebrides. About 50 species are known but many others are surely waiting for description because this interesting, large, genus needs to be revised. Brauer named the genus after the curved costa (the external vein of the wings), deriving it from the Greek ανκυλος [ankylos] crooked, bent, curved, hooked and πτερον, πτερυξ [pteron, pteryx] wing. Manifest characters of the genus are the highly setose wings, forewings with very broad costal field, narrow hind wings, and, strangely, tarsi with black tips. Alive specimens show an unusual resting position, with the wings flattened and not folded in a roof-like position. Tjeder (1966, The Lace-wings of Southern Africa. 5. Family Chrysopidae. South African Animal Life. Vol. 12.) suggested that this peculiarity is probably due to the broad costal area. Presumably, the resting position, in connection with the broad and setose wings, allows to improve the adhesiveness to the large and smooth leaves of the tropical plants, on which these species find shelter. As far as is known, the adults are not predaceous and the larvae are trash-carrying, i.e. they cover themselves with debris, resembling small packets of fragments thanks to the large setose tubercles and long body hairs. *Ankylopteryx* species were cited as predators in crops and orchards, indeed applied studies suggest their potential role as biological control agents.

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Ankylopteryx sp. pl.: Up: Ulu Yam, Selangor, Malaysia (forest); middle: Nilai, Negeri Sembilan, Malaysia (open area); down: Bentong, Pahang, Malaysia (montane Forest, about 830 m asl)

Biodiversity Journal, 2014, 5 (1): 3–8

Diversity and distribution of Coccinellidae (Coleoptera) in Lorestan Province, Iran

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ABSTRACT The present study was conducted from April to September 2012 to assess biodiversity and distribution of Coccinellids (Coleoptera Coccinellidae) in five regions of the west of Lorestan Provine, Iran. Specimens of coccinellid beetles were collected by netting and hand picking from Shorab, Veisian, Sarabdore, Teshkan and Kashkan. Identification of these beetles showed twenty-two different species. *Oenopia conglobata* (Linnaeus, 1758) (n = 386, 24%) was recorded as the most abundant species as well as widely distributed on all over the regions. When distributions of all the areas were compared, it was concluded that Coccinellidae was mostly distributed in the Shorab area. The maximum and minimum species diversity indices were obtained in Shorab (Simpson's diversity index = 0.90) and Kashkan (Simpson's diversity index = 0.67) regions, respectively. Maximum similarity index (0.89) was observed between Sarabdore and Kashkan regions.

KEY WORDS Ladybirds; biodiversity; Coleoptera; Iran.

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INTRODUCTION

About 6000 species of Coccinellids, Ladybird beetles, (Coleoptera Coccinellidae) are known worldwide (Vandenberg, 2002). They are of great economic importance as predators both in their larval and adult stages on various important crop pests such as aphids, coccids and other soft bodied insects (Hippa et al., 1978; Kring et al., 1985). Coccinellids undergo complete metamorphosis with distinct egg, larval, pupal and adult stages. Their life cycle is completed in one month depending upon prey, location and temperature; two or three generations are generally produced in a year. Adults overwinter in sheltered locations such as tree holes and other natural hiding places (Majerus & Kearns, 1989). The coccinellidae are an important group of beetles from both an economic standpoint in their use as biological control agent and in their diversity and adaptation to a number of differing habitats. The coccinellid beetles are considered to be of a great economic importance in agro-ecosystems thanks to their successful employment in biological control of many injurious insects (Agarwala & Dixon, 1992). The observed degree of their adaptation as well as their efficiency in controlling aphid populations varies with the species and the environmental conditions (Dixon, 2000). Indeed, Coccinellidae are extremely diverse in their habits: they live in all terrestrial ecosystems (Skaife, 1979). They are also regarded as bioindicators (Iperti, 1999) and provide more general information about the ecosystem in which they occur (Andersen, 1999). Iran is an ecologically diversified country which includes rich

agricultural areas, deserts, marshes, rivers and mountain habitats. Because of these specialized geographic and vegetative zones, Djavanishir (1976) grouped the Iranian vegetation coverage into five zones, including the Irano-Touranian floristic zone that encompasses the most extensive area of Iran. In the confluence of these different climatic and geographic zones, a rich faunal assemblage is expected for the country. Unfortunately, there are very few references in the literature about distribution and diversity of ladybird beetles in Iran. The objectives of the present study were to explore the predatory ladybird fauna of Lorestan Province (Iran), to estimate the species richness, species evenness and species diversity of Coccinellids in agro-ecosystems and to know about the role of Coccinellids as bioindicators.

MATERIAL AND METHODS

The Chegeni (west of Lorestan province) is located between longitude 48°02' East, latitude 31°32' North of Iran. It has moderate weather, with the average temperature in summer reaching 35 °C and average annual rainfall of about 350 mm, which is sufficient to keep the soil very fertile. This area consists of a lot of fruit orchards. The study area was divided in five sampling regions, namely: Shorab, Veisian, Sarabdore, Teshkan and Kashkan. Collection of beetles was done from different parts of these regions during 2012, from early spring to the autumn season. Each locality was frequently visited weekly. All the available trees were selected for the sampling and it continued for the total duration of 6 months. The adult ladybird specimens on the trees, crops and weeds were collected randomly by netting, hand picking and light trapping. The specimens were collected daily and were preserved in vials containing 75% ethanol, and then pinned and placed in collection boxes. Each specimen was labeled noting the place of collection, date of collection, pray name and host plant species and brought to the laboratory of Islamic Azad Borujerd University, Borujerd for biodiversity count. All specimens were manually stored and identified to species level with the help of available literature and already identified specimens which are preserved in the insect Museum of Islamic Azad Borujerd University. Collected data were employed for stastistical analyses to calculate species diversity, abundance and similarity in different places, crops and periods by applying Simpson's diversity index and Sorenson index.

Simpson's index (D) is a measure of diversity. The formula for calculating D is presented as:

$$D = \frac{\sum n_i(n_i - 1)}{N(N-1)}$$

where n_i = the total number of organisms of each individual species, N = the total number of organisms of all species and 1-D= Simpson's diversity index, 1/D= Simpson's reciprocal index.

The value of D ranges from 0 to 1. With this index, 0 represents infinite diversity and 1 no diversity. That is, the bigger the value the lower the diversity. This does not seem intuitive or logical, so some texts use derivations of the index, such as the inverse (1/D) or the difference from 1 (1-D) (Magurran, 1988).

Species similarity

Species similarity between two communities was calculated by Sorenson's index (SQ)

$$SQ = \frac{2J}{(a+b)}$$

where J = number of similar species in both communities; a = total number of species in community A, b = total number of species in community B.

The value of SQ ranges from 0 to 1. With this index, 0 represents no similarity and 1 complete similarity. That is, the bigger the value the higher the similarity (Southwood & Henderson, 2000).

RESULTS

The present study was conducted from April to September 2012. Table 1 shows the list of Coccinellid species captured in the examined regions. The maximum and minimum numbers of species were found in subfamilies Coccinellinae and Chilochorinae respectively. Among genera, *Exochomus* Redtenbacher, 1843 and *Scymnus* Kugelann, 1794 were the most abundant. *Oenopia conglobata*, *Coccinella septempunctata*, *Adalia decimpunctata*, *Scymnus apetzi*, *Scymnus syriacus* and *Hippodamia variegata* were found in all places of sampling.

Regions Species	Shorab	Veisian	Sarab-doreh	Teshkan	Kashkan	Total number
Coccinella septempunctata Linnaeus, 1758	+	+	+	+	+	265
Hippodamia variegata (Goeze, 1777)	+	+	+	+	+	332
Adalia bipunctata (Linnaeus, 1758)	+	-	+	+	-	35
Adalia decimpunctata (Linnaeus, 1758)	+	+	+	+	+	53
Oenopia conglobata (Linnaeus, 1758)	+	+	+	+	+	386
Oenopia oncina (Olivier, 1808)	+	-	-	-	-	81
Psyllobora vigintidupunctata (Linnaeus, 1758)	+	+	-	-	-	3
Propylea quatuordecimpunctata (Linnaeus, 1758)	+	-	-	-	-	56
Scymnus syriacus (Marseul, 1868)	+	+	+	+	+	90
Scymnus apetzi Mulsant, 1846	+	+	+	+	+	45
Scymnus araraticus Iablokoff-Khnzorian, 1969	+	-	-	-	-	8
Scymnus pallipes Mulsant, 1850	+	-	-	-	-	3
Scymnus nubilus Mulsant 1850	+	-	-	-	-	8
Stethorus punctillum Weise, 1891	+	-	-	-	-	4
Stethorus gilvifrons (Mulsant, 1850)	+	+	+	+	+	44
Exochomus melanocephalus (Zoubkoff, 1833)	+	-	-	-	-	4
Exochomus nigromaculatus (Goeze, 1777)	+	+	-	-	-	10
Exochomus quadripustulatus (Linnaeus, 1758)	+	+	-	-	-	34
Exochomus pubescens Küster, 1848	+	-	+	-	-	71
Exochomus undulatus Weise, 1878	+	+	+	-	+	11
Chilocorus bipustulatus Linnaeus, 1758	+	+	-	-	-	12
Tyttaspis sedecimpuntata (Linnaeus, 1758)	-	+	-	-	-	2

Table 1. Distribution and total number of Coccinellids species collected in sampling localities.

Among them, *Oenopia conglobata* was eudominant in all sites under study, as it numbered 386 specimens, which made up 34% of all individuals. The second most abundant species was *H. variegata* (21%) and the next *C. septempunctata* (17%); Shorab showed the maximum species richness (21 species) and Veisian was the second one (13 species). As far as concerns the species abundance, *C. septempunctata* had maximum abundance in Veisian region and *H. variegata* in Sarabdoreh region. All percentages are listed in Table 2. Diversity and reciprocal indices in different places were calculated by Simpson's index. This index considers both the number of species and the distribution of individuals among species. Simpson diversity and reciprocal indices of all examined places are reported in Table 3.

Regions Species	Shorab	Veisian	Sarab- doreh	Teshkan	Kashkan
Coccinella septempunctata Linnaeus, 1758	12.7	29.3	13.2	15.8	20.7
Hippodamia variegata (Goeze, 1777)	7.9	20.5	35.6	35.5	8.5
Adalia bipunctata (Linnaeus, 1758)	3.2	-	3.5	1.9	-
Adalia decimpunctata (Linnaeus, 1758)	1.5	2.1	5.4	3.8	6.4
Oenopia conglobata (Linnaeus, 1758)	24.7	21.9	15.9	25	53.5
Oenopia oncina (Olivier, 1808)	15.6	-	-	-	-
Psyllobora vigintidupunctata (Linnaeus, 1758)	0.38	0.36	-	-	-
Propylea quatuordecimpunctata (Linnaeus, 1758)	10.8	-	-	-	-
Scymnus syriacus (Marseul, 1868)	2.3	7.3	7.3	10	3.5
Scymnus apetzi Mulsant, 1846	1.7	2.5	4.6	3.8	1.4
Scymnus araraticus Iablokoff-Khnzorian, 1969	1.5	--	-	-	-
Scymnus pallipes Mulsant, 1850	1.5	-	-	-	-
Scymnus nubilus Mulsant 1850	0.77	-	-	-	-
Stethorus punctillum Weise, 1891	0.77	-	-	-	-
Stethorus gilvifrons (Mulsant, 1850)	2.7	2.5	3.5	3.8	1.4
Exochomus melanocephalus (Zoubkoff, 1833)	0.77	-	-	-	-
Exochomus nigromaculatus (Goeze, 1777)	1.3	1	-	-	-
Exochomus quadripustulatus (Linnaeus, 1758)	2.9	6.5	-	-	-
Exochomus pubescens Küster, 1848	0.96	-	1.6	-	-
Exochomus undulatus Weise, 1878	3.6	3.6	9.2	-	5.7
Chilocorus bipustulatus Linnaeus, 1758	1.7	1.09	-	-	-
Tyttaspis sedecimpuntata (Linnaeus, 1758)	-	0.73	-	-	-

Table 2. Abundance percentage of Coccinellids in sampling localities.

Regions of sampling Index of diversity	Shorab	Veisian	Sarabdoreh	Teshkan	Kashkan
Simpsons diversity index (1-D)	0.90	0.81	0.81	0.77	0.67
Simpsons reciprocal index(1/D)	10.01	5.36	5.29	4.42	3.39

Table 3. Simpsons diversity indices of Coccinellids in examined regions.

Regions of sampling	Shorab	Veisian	Sarabdoreh	Teshkan	Kashkan
Shorab	1	0.7	0.64	0.55	0.55
Veisian	0.69	1	0.69	0.6	0.76
Sarabdoreh	0.64	0.69	1	0.87	0.89
Teshkan	0.54	0.6	0.87	1	0.87
Kashkan	0.55	0.76	0.89	0.87	1

Table 4. Similarity indices of ladybird species in examined regions of sampling.

As shown, the highest and lowest values were obtained in Shorab (0.90) and Kashkan (0.67) regions, respectively (Table 3). The Minimum value of similarity index (0.54) was found comparing Teshkan and Shorab; and the maximum value (0.89) was between Sarabdoreh and Kashkan (Table 4).

DISCUSSION AND CONCLUSIONS

A previous similar survey of predatory Coccinellid beetles at Lorestan provinces (Iran) was conducted by Jafari & Kamali (2007). Present results (Table 1) confirm that Coccinellids are the most important group among crops and orchards predators in Iran (Modarres-Awal, 1997). Farahbakhsh (1961) reported the dominance of *P. quatrodecimpunctata*. According to Hodek & Honek (1996) and Majerus & Majerus (1996), *C. septempunctata* is the pronest to a sudden population growth as its number largely depends on the number of aphids. Generally, Coccinellids are density-dependent predators, i.e. their number rises as the prey number increases (Dixon, 2000). All species, belonging to the Scymnini, can be potential predators of pseudococcids, at least in the adult stage (Magro, 1992). Most of these species were recorded in Iran on a variety of plants by Borumand (2000). Jafari (2011) reported that *H. variegata* had rapidly established itself throughout the west of Iran (Lorestan Provinces) thanks to a successful feeding. The present work shows the extreme richness of the Coccinellid fauna in Lorestan. Dixon (2000) believes that the number of species largely depends on the number of preys. For example, in September most of pests yield great populations, thus the amount of feeding for Coccinellids increases too. The predaceous role of Coccinellids benefits from the maintenance of field diversity, which supports the population of prey such as aphids, thrips and mites (Iperti, 1999). Ladybird beetles migrate between various crop fields throughout the season depending upon the availability of prey and habitat disturbance (Maredia et al.,1992). We hope that this inventory of Coccinellid species in the Lorestan areas will contribue to improve Integrated Pest Management in crops and orchards in Iran by reducing or selecting pesticides for less impact on animal and botanical species and, above all, rearing and releasing those ladybird species which are recognized to be effective in pest control.

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The marine fossils malacofauna in a Plio-Pleistocene section from Vallin Buio (Livorno, Italy)

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ABSTRACT In the present paper the occurrence of marine fossil malacofauna in a Plio-Pleistocenic section from Vallin Buio (surroundings of Livorno) is described. Three different mollusc associations are present. The oldest one is typical of the Italian Lower Pliocene, the other two, are characteristic of the Upper Pleistocene fauna. Specimens, sometime poorly preserved, are not numerous for each section, but all the identified species are compatible with the respective fossil associations. The fossil malacofauna in the calcarenitic level referred to the Upper Pleistocene shows a remarkable affinity with the biotic component of the *posidonietum* biocenosis.

KEY WORDS Pliocene; Upper Pleistocene; molluscs; posidonietum;Vallin Buio; Livorno.

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INTRODUCTION

In the present paper the occurrence of a marine fossil malacofauna, detected in 1999 by two of the authors (AC and MF), in a Plio-Pleistocenic section in Vallin Buio (Cisternino), in the surroundings of Livorno, is described.

The most interesting level in limestone, infringing on the underlying Pliocenic one, includes a poorly preserved malacofauna that, however, shows a strong affinity with the mollusk community of the current biocenosis of the marine ecosystem called “Posidonieto”, *Posidonietum oceanicae* (Funk, 1927) Molinier, 1958.

The study in detail of the malacofauna from Cisternino (Livorno) was previously performed by Bogi & Cauli (1997) and Cauli & Bogi (1997-98), limited to an outcrop of Pliocene sediments, the same as those occurring in the lower part of the section, outcropping about a kilometer south-east from Vallin Buio. Additional data were taken from reports of the IX meeting of the Italian Palaeontological Society including several contributions on the eastward malacofauna occurring, on the so-called "Sezione degli Archi", with layers from the Upper Miocene to the Middle Pleistocene (Bossio et al., 1981).

MATERIAL AND METHODS

The largest molluscs were collected manually in the various levels of the section, while, by sieving approximately 5 dm³ of the reddish sand interspersed with and included within the limestone, some species smaller in size have been identified; the poor state of conservation of this finer fraction allowed us to find only a few specimens.

ABBREVIATIONS. AC = A. Ciampalini; d = maximum diameter; exx = exemplares; h = height; l = width; m asl = meters above sea level; MF = M. Forli. For cartography and acronyms used in the text we referred to the Geological Map of Tuscany, Scale 1:10,000 (CARG project).

Geological setting

The peculiarity of the geological section under study, outcropping over a cliff near Vallin Buio (Livorno), is to have the Upper Pleistocene sediments resting in contact with those of the Pliocene without any other intermediate Pleistocenic layer. The section is located along the provincial road of "Sorgenti" on the right of "Rio Valle Lunga"; this section was highlighted as a result of an excavation for the construction of the road, in the direction of the Ugione stream, 43°34'05" N - 10°21'06"E, 8 m asl (Fig. 1).

The section develops with a maximum thickness of about 3 meters and a length of 20/30 meters degrading in both directions. Currently it is in a poor state of preservation. Its appearance has been modified by some small landslides which prevented the observation in minute detail of the reciprocal arrangement between Pliocene limestone and clay, even if it is still possible to roughly reconstruct the original arrangement of the overlying strata.

The levels of interest, not mapped in the Geological Map of Tuscany 1:10,000 (CARG project) because of their small thickness, present to the bed a layer of about 1 meter attributed to the formation of the Blue Clay (FAA = p of the geological map 1:25,000 of Livorno Province) of the marine environment, from neritic to upper bathyal and chronologically attributed to the Pliocene (Barsotti et al., 1974), and to the roof a layer of about 100-130 cm thick represented by the Red Sands of Donoratico (QSD = former q_9 of the 1:25,000 map, cf. Sands of Ardenza), that may be referred to a continental environment (aeolian, colluvial and of alluvial plain) attributable to the Upper Pleistocene.

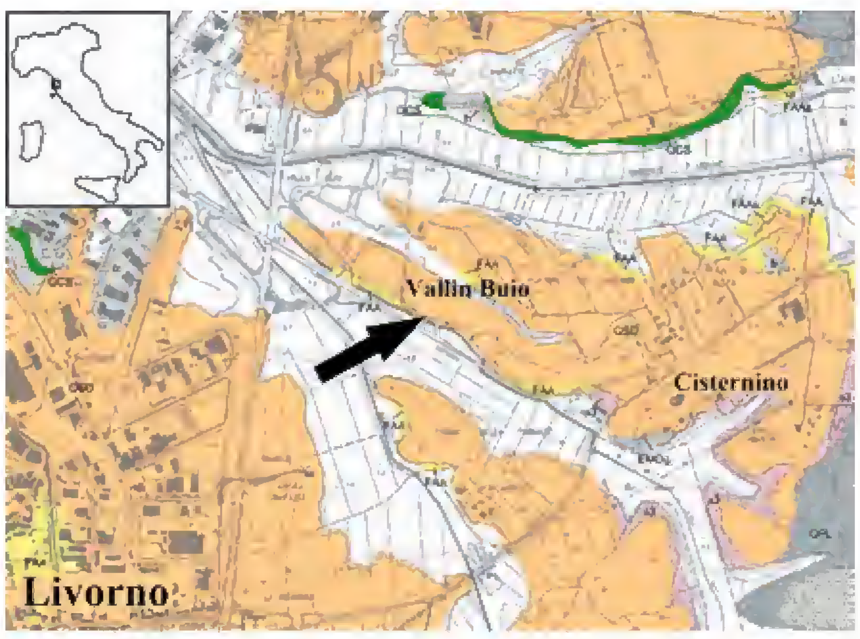


Figure 1. Study area from Geological Map of Tuscany, Scale 1:10,000 (CARG Project).

In the sands of Donoratico, on the terrace of Livorno and also nearby Vallin Buio, Ajaccia, Lupinaio, and Campacci (Sammartino, 1989; Ciampalini & Sammartino, 2007) were found some Middle-Paleolithic artifacts that confirm the attribution of the summit sands of the section to the Sands of Ardenza (Malatesta, 1940). The middle layer, about 80-100 cm thick, which lies in transgression on blue clay (FAA) and consists of a calcarenite with many bioclasts, remnants of marine gastropods and bivalves and few pebbles, is attributable lithologically to the "Panchina" layer (see Castiglioncello Calcarenites Formation cartography 1:25,000) (QCP = q_8).

Malatesta (1942) described small outcrops of the "Panchina" formation to the east of Livorno, near the Cigna little bridge, at the "Fornaci Anelli", at Porcarecce, in "Santo Stefano ai Lupi" and also in the area of Cisternino. The outcrop was previously studied by the stratigraphic standpoint by one of the authors (Ciampalini, 2002) and, at present, we refer to this work because now the exposure is no longer visible with the initial definition. The succession showed above the substrate consisting of blue clay slightly altered and abundant carbonate nodules, a level of marine calcarenites (maximum thickness of 100 cm) followed by a layer of polygenic gravel in a reddish matrix here and there with clastic rocks (maximum diameter 2-3 cm) of 30/40 cm, and finally, in likely continuity, a layer with a max thickness of 100-130 cm formed by reddish sands, presumably from an ancient dune (Fig. 2).

RESULTS

In the upper part of the layer with a calcarenitic base only two species of gastropods and two of bivalves were found (Table 1), with well-preserved

specimens (showing original colors). However, all of them agree with a single depositional facies, relating to a brackish environment with sedimentation of fine sand. These specimens were taken just below the polygenic gravels (see section of Vallin Buio in figure 2). These molluscs are to be considered a little more recent than those present within the calcarenite (Figs. 3–10).

Most fossils come from the calcarenite and compressed sands either included within or filling the cavities (Table 2). The quality of preservation is very poor because the shells are often eroded and fragmented. This is partly due to the softening of the shell because of water percolating from the upper layer and partly to the mode of fossilization itself.

However, even if battered, the species can be identified. There are three Polyplacophora, thirty-five gastropods, thirty bivalves and two Scaphopoda; among gastropods the most abundant are *Cerithium vulgatum* Bruguière, 1792, *Tricolia speciosa* (Mühlfeld, 1824), *Bolma rugosa* (Linnaeus, 1758) with other species referable to the same type of environment, i.e. *Posidonia* prairies (Peres & Picard, 1964; Barsotti et al., 1974).

Among Bivalvia, remains of *Glycymeris glycymeris* (Linnaeus, 1758) are the most abundant with forty valves and a complete specimen, though small in size, about 3 cm, followed by *Chamelea gallina* (Linnaeus, 1758) with eighteen shells, small compared to the average size of the species, which suggests a selective post-mortem transport, since all the bivalves examined are more or less of the same size.

The only remains that seem to be in situ are those of *Spondylus gaederopus* (Linnaeus, 1758) included within the limestone but not in the sands inside the cavities. The biggest one, although incomplete, is over 7 cm tall, from the apex to the opposite edge of the shell. In the absence of a complete paleo-ecological study, due to the lack of samples and subsequent counts of specimens carried out properly, it can reasonably be assumed that molluscs occurring in this level lived in a marine environment of sandy bottom alternating to or near to *Posidonia* prairies, the so-called "posidonieti" (Figs. 11–42) typical of the infralittoral, which is also confirmed by the presence of Poliplacophora that for the upper Pleistocene sediments of the surroundings of Livorno, are known exclusively from this location (Dell'Angelo et al., 2001).

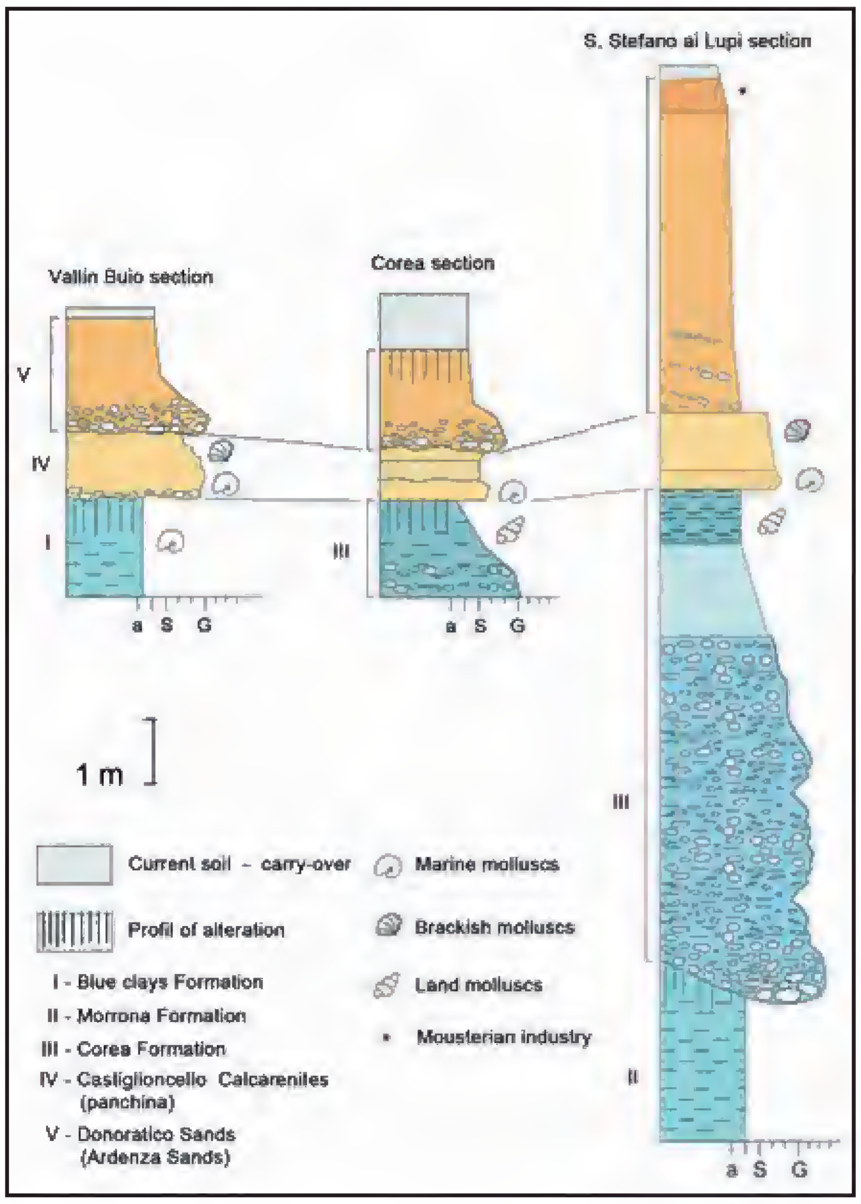


Figure 2. Stratigraphic columns of the sections of "Vallin Buio", "Corea" (from Ciampalini et al., 2006), modified; and of "Santo Stefano ai Lupi" (from Malatesta, 1940, 1942), modified and updated.

Species	N. exx.	Level
GASTROPODA		
Nassarius mutabilis (Linnaeus, 1758)	1	IV
Cyclope neritea (Linnaeus, 1758)	1	IV
BIVALVIA		
Cerastoderma glaucum (Bruguière, 1789)	3	IV
Donax trunculus Linnaeus, 1758	1	IV

Table 1. List and amount of molluscs found in the upper part of the layer IV of the Vallin Buio section shown in figure 2.

In the lower part of the section, attributable to the Lower Pliocene, eight species of Gastropoda, three of Bivalvia and three of Scaphopoda were recovered (Table 3). For a detailed discussion of the Pliocene fauna see Bogi & Cauli (1997) and Cauli

Figures 3, 4. *Nassarius mutabilis* (Linnaeus, 1758) d=14 mm., h=20.5 mm. Figures 5, 6. *Cyclope neritea* (Linnaeus, 1758) d=12 mm., h=6.3 mm.; Figures 7, 8. *Donax trunculus* (Linnaeus, 1758) l=21 mm., h=13 mm. Figures 9, 10. *Cerastoderma glaucum* (Bruguiére, 1798) l=22.4 mm., h=21 mm.

& Bogi (1997-98), who extensively described and discussed the same malacofauna, coming from a place at south-east of the small valley where the outcrop described herein is located. Among the species found in Vallin Buio two not previously reported by these authors are listed below (Figs. 43–59).

GASTROPODA Cuvier, 1795
PATELLOGASTROPODA Lindberg, 1986
LOTTIOIDEA Gray, 1840
LOTTIDAE Gray, 1840
Tectura Gray, 1847

Tectura virginea (O.F. Müller, 1776) (Fig. 52)

One specimen, of average size (3 mm. in length), a little eroded with damaged margins. The species is reported from the Miocene and currently lives on muddy bottoms of the intertidal plan (Chirli, 2004).

CAENOGASTROPODA Cox, 1960
STROMBOIDEA Rafinesque, 1815
APORRHAIDAE Gray, 1850
Aporrhais da Costa, 1778

Aporrhais peralata (Sacco, 1893) (Figs. 45–47)

One specimen of average size (d = 8.5 mm.; h = 17.3 mm.) with broken digit ends, but, overall, the shell is definitely recognizable. The species is reported for various locations of Central and Northen Italy in deep Pliocenic clay sediments (Brunetti & Forli, 2013).

DISCUSSION AND CONCLUSIONS

The fossil molluscs of the Pliocenic sediments are compatible with those listed and described by

	Species	N. exx.	Level
	POLYPLACOPHORA		
1	*Lepidopleurus cajetanus* (Poli, 1791)	10	IV
2	*Chiton olivaceus* Spengler, 1797	1	IV
3	*Acanthochitona fascicularis* (Linnaeus, 1767)	1	IV
	GASTROPODA		
1	*Tectura virginea* (O.F. Müller, 1776)	3	IV
2	*Diodora graeca* (Linnaeus, 1758)	2	IV
3	*Gibbula ardens* (Von Salis, 1793)	1	IV
4	*Jujubinus esasperatus* Pennant, 1777	7	IV
5	*Clanculus cruciatus* (Linnaeus, 1758)	2	IV
6	*Clanculus jussieui* (Payraudeau, 1826)	2	IV
7	*Calliostoma* sp.	2	IV
8	*Bolma rugosa* (Linnaeus, 1758)	5	IV
9	*Homalopoma sanguineum* (Linnaeus, 1758)	1	IV
10	*Tricolia pullus* (Linnaeus, 1758)	42	IV
11	*Tricolia tenuis* (Michaud, 1829)	14	IV
12	*Tricolia speciosa* (Mühlfeld, 1824)	7	IV
13	*Smaragdia viridis* (Linnaeus, 1758)	1	IV
14	*Bittium reticulatum* (da Costa, 1778)	28	IV
15	*Cerithium vulgatum* Bruguière, 1792	16	IV
16	*Monophorus* sp.	6	IV
17	*Rissoa* sp.	1	IV
18	*Alvania cimex* (Linnaeus, 1758)	1	IV
19	*Alvania discors* (Allan, 1818)	9	IV
20	*Alvania geryonia* (Nardo, 1847)	1	IV
21	*Alvania mamillata* Risso, 1826	4	IV
22	*Crisilla semistriata* (Montagu, 1808)	1	IV
23	*Caecum trachea* (Montagu, 1803)	2	IV
24	*Vermetus triquetrus* Bivona Ant., 1832	1	IV
25	*Calyptraea chinensis* (Payraudeau, 1826)	1	IV
26	*Euspira guilleminii* (Linnaeus, 1758)	1	IV
27	*Hexaplex trunculus* (Linnaeus, 1758)	1	IV
28	*Columbella rustica* (Linnaeus, 1758)	1	IV
29	*Euthria cornea* (Linnaeus, 1758)	1	IV
30	*Chauvetia brunnea* (Donovan, 1804)	1	IV
31	*Cyclope pellucida* Risso, 1826	1	IV
32	*Conus ventricosus* Gmelin, 1791	5	IV
33	*Mangelia* sp.	1	IV
34	*Turbonilla rufa* (Philippi, 1836)	1	IV
35	*Turbonilla pusilla* (Philippi, 1844)	1	IV
	BIVALVIA		
1	*Nucula nucleus* (Linnaeus, 1758)	2	IV
2	*Saccella commutata* (Philippi, 1844)	1	IV
3	*Arca noae* (Linnaeus, 1758)	1	IV
4	*Barbatia barbata* (Linnaeus, 1758)	6	IV
5	*Barbatia clathrata* (Defrance, 1816)	2	IV
6	*Striarca lactea* (Linnaeus, 1758)	1	IV
7	*Glycymeris glycymeris* (Linnaeus, 1758)	47	IV
8	*Glycymeris insubrica* (Brocchi, 1814)	11	IV
9	*Limopsis* cf. *aurita* (Brocchi, 1814)	1	IV
10	*Cardita calyculata* (Linnaeus, 1758)	4	IV
11	*Goodallia triangularis* (Montagu, 1803)	11	IV
12	*Flexopecten flexuosus* (Poli, 1795)	2	IV
13	*Spondylus gaederopus* (Linnaeus, 1758)	3	IV
14	*Lima lima* (Linnaeus, 1758)	6	IV
15	*Anomia ephippium* (Linnaeus, 1758)	1	IV
16	*Ostrea stentina* Payraudeau, 1826	1	IV
17	*Ctena decussata* (Costa O.G., 1829)	1	IV
18	*Myrtea spinifera* (Montagu, 1803)	1	IV
19	*Lucinella divaricata* (Linnaeus, 1758)	15	IV
20	*Chama gryphoides* (Linnaeus, 1758)	11	IV
21	*Angulus tenuis* (da Costa, 1778)	1	IV
22	*Moerella donacina* (Linnaeus, 1758)	1	IV
23	*Donax* sp.	4	IV
24	*Laevicardium crassum* (Gmelin, 1791)	1	IV
25	*Papillicardium papillosum* (Poli, 1791)	13	IV
26	*Dosinia exoleta* (Linnaeus, 1758)	4	IV
27	*Chamelea gallina* (Linnaeus, 1758)	32	IV
28	*Venus verrucosa* (Linnaeus, 1758)	12	IV
29	*Pitar rudis* (Poli, 1795)	1	IV
30	*Corbula gibba* (Olivi, 1792)	30	IV
31	*Rocellaria dubia* (Pennant, 1777)	1	IV
	SCAPHOPODA		
1	*Antalis vulgaris* (da Costa, 1778)	2	IV
2	*Cadulus gibbus* Jeffreyes, 1883	1	IV

Table 2. List and amount of molluscs found in the lower part of the layer IV of the Vallin Buio section shown in figure 2.

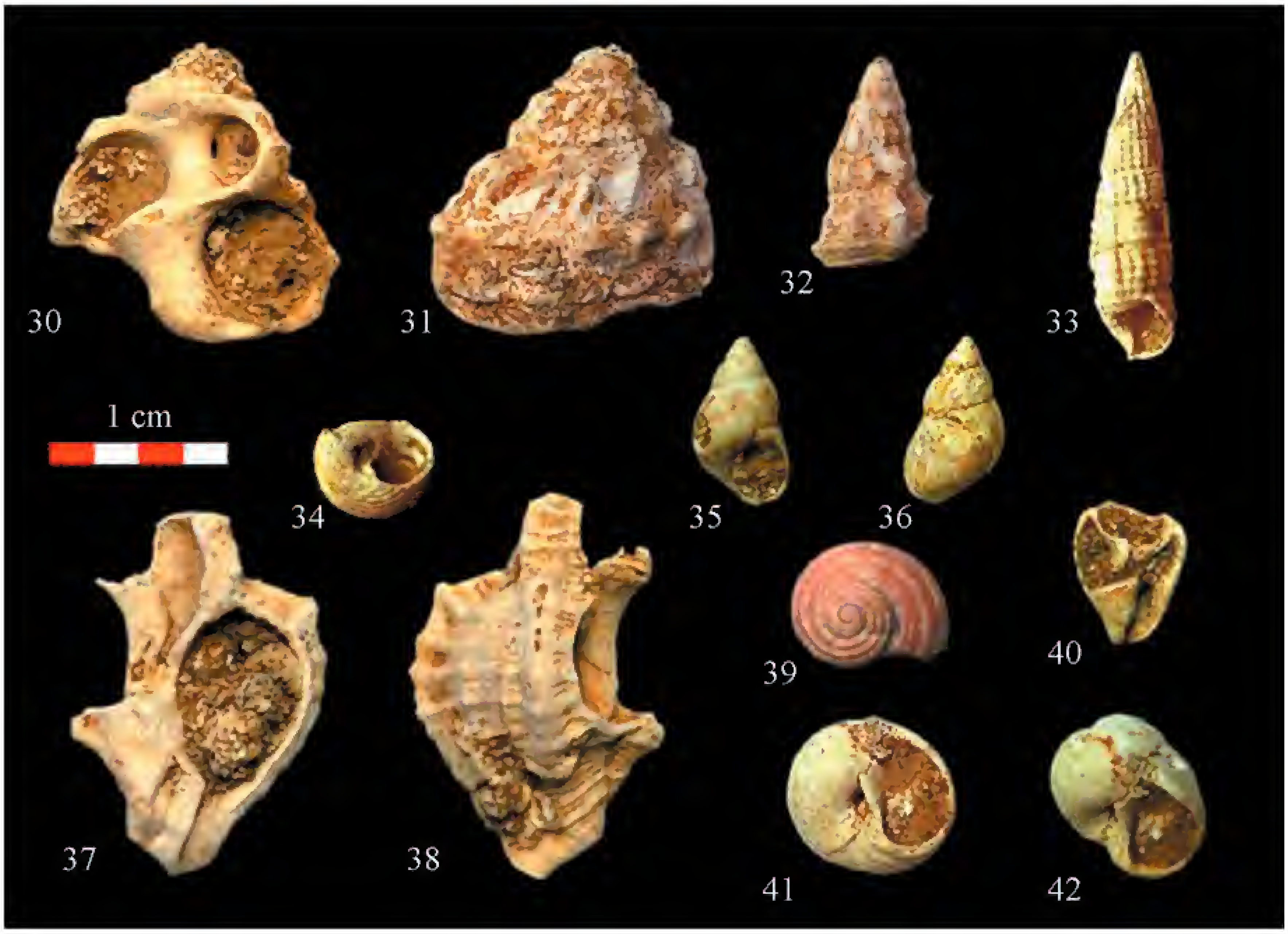
Figures 11, 12. *Rocellaria dubia* (Pennant, 1777) internal/external model l=32 mm., h=12.5 mm. Figures 13, 14. *Chamelea gallina* (Linnaeus, 1758) l=12.4 mm., h=11mm. Figures 15, 16. *Dosinia exoleta* (Linnaeus, 1758) l=22.4 mm., h=21.7 mm. Figure 17. *Flexopecten flexuosus* (Poli, 1795) l=14 mm., h=14 mm. Figure 18. *Barbatia barbata* (Linnaeus, 1758) l=26.4 mm., h=13.5 mm. Figures 19, 20. *Papillicardium papillosum* (Poli, 1791) l=11.6 mm., h=12 mm. Figures 21, 22. *Venus verrucosa* (Linnaeus, 1758) l=24.4 mm., h=22.5 mm. Figures 23-25. *Glycymeris glycymeris* (Linnaeus, 1758) l=33.3 mm., h=33.2 mm.; Figure 26. *Lima lima* (Linnaeus, 1758) l=27 mm., h=20 mm. Figures 27, 28. *Ostreola stentina* Payraudeau, 1826 l=32.4 mm., h=24.3 mm. Figure 29. *Spondylus gaederopus* (Linnaeus, 1758) l=33 mm., h=28.5 mm.

	Species	N. exx.	Level
	GASTROPODA		
1	*Tectura virginea* (O.F.Müller, 1776)	1	I
2	*Turritella spirata* (Brocchi, 1814)	4	I
3	*Aporrhais peralata* (Sacco, 1893)	1	I
4	*Euspira helicina* (Brocchi, 1814)	5	I
5	*Nassarius cabrierensis* (Fontannes, 1878)	3	I
6	*Nassarius italicus* (Mayer, 1876)	3	I
7	*Turricula dimidiata* (Brocchi, 1814)	2	I
8	*Stenodrillia allionii* (Bellardi in Seguenza, 1875)	1	I
	BIVALVIA		
1	*Nucula piacentina* Lamarck, 1819	1	I
2	*Bathyarca cf philippiana* (Nyst, 1848)	2	I
3	*Limopsis aurita* (Brocchi, 1814)	1	I
	SCAPHOPODA		
1	*Dentalium sp.*	2	I
2	*Dentalium sexangulum* Gmelin, 1791	3	I
3	*Gadilina triquetra* (Brocchi, 1814)	1	I

Cauli & Bogi (1997–98) who consider the malacological paleo-communities as characteristic of muddy bottoms, corresponding to a transition zone separating the circalittoral and bathyal planes, dated between the end of Zanclean and the beginning of Piacenziano. Marine Mollusca in the formation of the "Sandy Calcarenites of Castiglioncello" (commonly called "Panchina") now reported as QCP (1:10,000 map, CARG project) is known in detail from a study carried out in the dry dock of the "Torre del Fanale" (Livorno) (Barsotti et al., 1974).

Table 3. List and amount of molluscs found in the Pliocenic clays, level I of the Vallin Buio section shown in figure 2.

Figures 30, 31. *Bolma rugosa* (Linnaeus, 1758). Figure 32. *Cerithium vulgatum* Bruguière, 1792. Figure 33. *Bittium reticulatum* (da Costa, 1778) d=3 mm., h=11 mm. Figure 34. *Clanculus cruciatus* (Linnaeus, 1758). Figures 35, 36. *Tricolia speciosa* (Mühlfeld, 1824) d=4 mm., h=7.3 mm. Figures 37, 38. *Hexaplex trunculus* (Linnaeus, 1758); Figure 39. *Homalopoma sanguineum* (Linnaeus, 1758) x4; Figure 40. *Columbella rustica* (Linnaeus, 1758). Figure 41, 42. *Euspira guilleminii* (Payraudeau, 1826) d=9 mm., h=6 mm.



Figures 43, 44. *Strenodrilla allionii* (Bellardi in Seguenza, 1875), d=7 mm., h=22 mm. Figures 45-47. *Aporrhais peralata* (Sacco, 1893) d=8,5 mm., h=17,3 mm. Figures 48, 49. *Nassarius italicus* (Mayer, 1876) d=9,2 mm., h=18 mm. Figures 50, 51. *Limopsis aurita* (Brocchi, 1814) l=12 mm., h=13 mm. Figure 52. *Tectura virginea* (O.F. Müller, 1776); Figures 53, 54. *Bathyarca* cf. *philippiana* (Nyst, 1848) l=10.3 mm., h=7 mm. Figures 55, 56. *Turricula dimidiata* (Brocchi, 1814) d=10 mm., h=30.5 mm.; Figures 57, 58. *Euspira helicina* (Brocchi, 1814) d=12.4 mm., h=12 mm. Figure 59, *Turritella spirata* (Brocchi, 1814). 60. *Dentalium sexangulum* Gmelin, 1791 d=7 mm., h=38.5mm.

The level is devoid of "warm guests", particularly of those forms currently found along the Senegalese coasts, so it is possible that the layer belongs to more advanced stages of the Tyrrhenian transgression s.s. dating from 125 ka (MIS 5e).

Actually, even in the dry dock of Livorno (Barsotti et al., 1974) with the exception of the first 30-40 cm in which there were, among other forms, species typical of tropical seas warmer than the Mediterranean, in the rest of the section these species disappeared, being replaced by a "normal" fauna just as that found in the present study.

Malatesta (1942) reported that in the area of Santo Stefano ai Lupi at the base of the escarpment (Gronda dei Lupi) that divided the plain of Pisa from the "Terrace" of Livorno, emerged a bench in thin slabs of limestone with some rests of marine fauna. Towards the top there was an increase in sand fraction, and at the same time the fauna became more and more scarce until it consisted of a few brackish forms, with above all layers reddish dune-sand. Bacci et al. (1939) taking into account data from surveys and field observations, suggested the following reconstruction of the series (see also Barsotti et al., 1974; Dall'Antonia & Mazzanti, 2001; Ciampalini, 2002), from the roof to the bed: slightly clayey sand ending with a soil, very fine reddish aeolian sand with evidence of stratification; coarser reddish dune-sand; small cross-bedding gravel, reddish sand with brackish fauna; bench irregularly cemented or sand with calcareous granules and beach fauna ever more clayey towards the base; continental clay; grey sand; and pebbles.

Malatesta (in Bacci et al., 1939) considered the layers at the base of the section as part of the Tyrrhenian transgression with a continental level intercalated, as confirmed by Barsotti et al. (1974) on the basis of the excavation of the dry dock of the “Torre del Fanale”, with sections showing the two benches separated by a continental layer. However, according to most recent studies, the layers below the “Panchina” (Panchina I Auct.) might belong to an intercalated cycle of the middle terminal Pleistocene, dating up to about 180 Ka (MIS 6), with fluvial gravel base separated by a surface of erosion from the silty clays of the Lower Pleistocene (Zanchetta et al., 2006; Ciampalini et al., in press).

In the Vallin Buio section the calcarenites with molluscs rely on the underlying Pliocenic clay sediments, showing sedimens at first of the "Panchina" type and then sandy, first with coarse-grained sedimentation and then thiner. Molluscs shown in figures 3–10 are from the upper part of this layer, immediately below the gravel and are most likely to be referred to a cooling phase, with more temperate climatic characteristics, dating to approximately 100–80 ka (MIS 5d–5b).

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Notes on the genus *Carabus* Linnaeus, 1758 (Coleoptera Carabidae) of Mount Bing-La-Shan, Xifeng County, Liaoning Province, Northeast China

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ABSTRACT The present work provides some preliminary data on the genus *Carabus* Linnaeus, 1758 collected from Mount Bing-La-Shan, Xifeng County, Liaoning Province, Northeast China. Thanks to these studies, some species show a greater distribution than previously known. In these locations is reported a new population of *Carabus* (*Carabus*) *xiuyanensis* Deuve et Li, 1998.

KEY WORDS carabid beetles; *Carabus*; faunistic; China.

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INTRODUCTION

The *Carabus* Linnaeus, 1758 (Coleoptera Carabidae) fauna in Northeastern China consists of two main faunal elements, the Euro-Siberian and Korean. The majority of the species are of large distribution with many very local subspecies (Kratz, 1881; Breuning, 1932-1936; Beheim & Breuning, 1943).

Only few endemic species, the endemics subgenera *Teratocarabus* Semenov et Znojko, 1932 and *Fulgenticarabus* Deuve et Li, 1998 contribute to the specificity of the fauna. Many taxa were described in the last years (Deuve Th. & Mourzine, 1998; Imura, 1991; Deuve, 1994; Deuve & Li, 2000a, 2000b; Rapuzzi, 2007).

Two of the authors (Lin Lin and Li Jingke) had the opportunity to investigate the Xifeng County in the northeastern part of Liaoning Province, China, bordering Jilin Province to the North and East.

MATERIAL AND METHODS

The investigated area is a Mountain area named Bing-La-Shan at the altitude between 700-750 m, it is on the first mountain spurs East from Dongbei Plains. *Carabus* were collected using pitfall traps in a forest area during the period 15/18 July 2012. Full data: Mt.Bing-La-Shan, alt.700-750 m, Liangquan Zhen, Xifeng County, Tieling City, Liaoning Province, July 15-18, 2012.

The studied specimens are preserved in the collection of one of the authors (I. Rapuzzi).

The adopted systematic order for the listed species of the genus *Carabus* is in accord with Deuve (2012).

Figure 1. Study area: Mount Bing-La-Shan, Xifeng County, Liaoning Province, Northeast China.

RESULTS

List of the species

Carabus* (*Aulonocarabus*) *rufinus rufinus Beheim et Breuning, 1943 (Fig. 2)

This subspecies is widespread in a large part of Liaoning Province and adjacent area of Jilin Province till Changbai Shan (Li, 2000; Deuve & Li, 2000a; Deuve et al., 2011; Zhang et al., 2013).

Carabus* (*Scambocarabus*) *kruberi cfr. ***laobeiensis*** Deuve et Li, 2000 (Fig. 3)

Only two females collected. The identification of the specimens will be confirmed after examination of males.

Carabus* (*Tomocarabus*) *fraterculus neochinensis Deuve et Li, 1998 (Fig. 4)

The subspecies is widespread from Liaoning to Heilongjiang Provinces.

Carabus* (*Morphocarabus*) *wulffiusi dekraatzi Kraatz, 1881 (Fig. 5)

By the small size the collected specimens belong to the subspecies *dekraatzi*, this form is common and widespread in the Northeast China (Deuve et al., 2011).

Carabus* (*Carabus*) *manifestus guanmenshuanus Imura, 1991(Fig. 6)

The subspecies is known from many localities from Liaoning Province and two from Jilin Province (Deuve et al., 2011; Zhang et al., 2013), the new locality is inside the range of the subspecies. The aedeagus in frontal and lateral views is figured (Figs. 7, 8).

Carabus* (*Carabus*) *xiuyanensis cfr. ***xiuyanensis*** Deuve et Li, 1998 (Fig. 9)

This species is very close to *C. manifestus* Kraatz, 1881 and *C. sternebergi* Roeschke, 1898 species group by the imago morphology but it has a different shape of male aedeagus (Figs. 10, 11). The typical form was described from Xiuyan Xian and up to now is known only by the holotype male, a second female specimen very probably belonging to *C. xiuyanensis* is preserved in the collection of one of the autors (I. Rapuzzi). The *C.* (*C.*) *xiuyanensis kuandianicus* Rapuzzi, 2007 is very well separate by the uncinate apex of aedeagus.

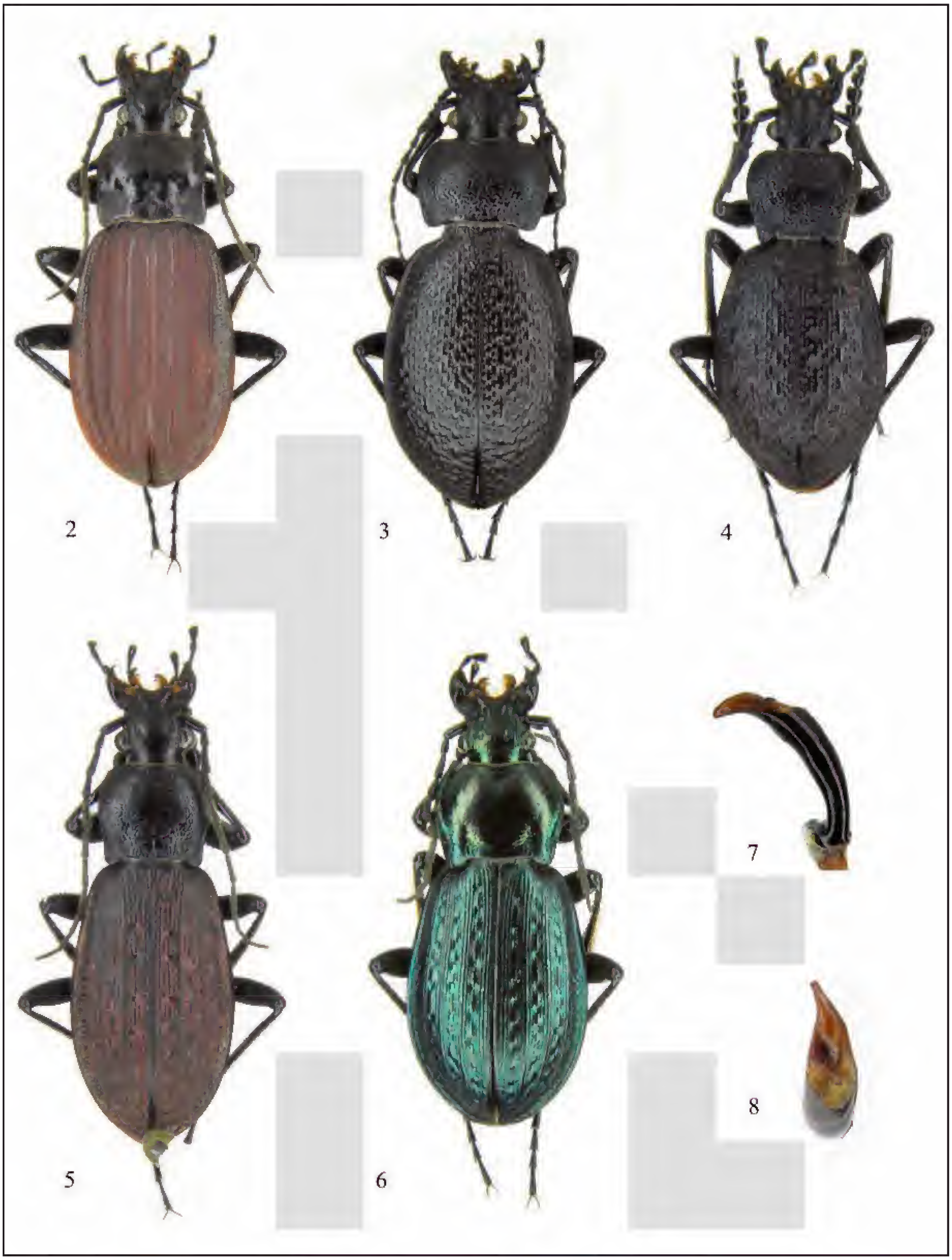

Figure 2. *Carabus* (*Aulonocarabus*) *rufinus* (28.5 mm). Figure 3. *C.* (*Scambocarabus*) *kruberi* cfr. *laobeiensis* (24.3 mm). Figure 4. *C.* (*Tomocarabus*) *fraterculus neochinensis* (18.7 mm). Figure 5. *C.* (*Morphocarabus*) *wulffiusi dekraatzi* (20.1 mm). Figure 6. *C.* (*Carabus*) *manifestus guanmenshuanus* (22 mm). Figures 7, 8: idem, aedeagus in lateral (Fig. 7) and frontal views (Fig. 8).

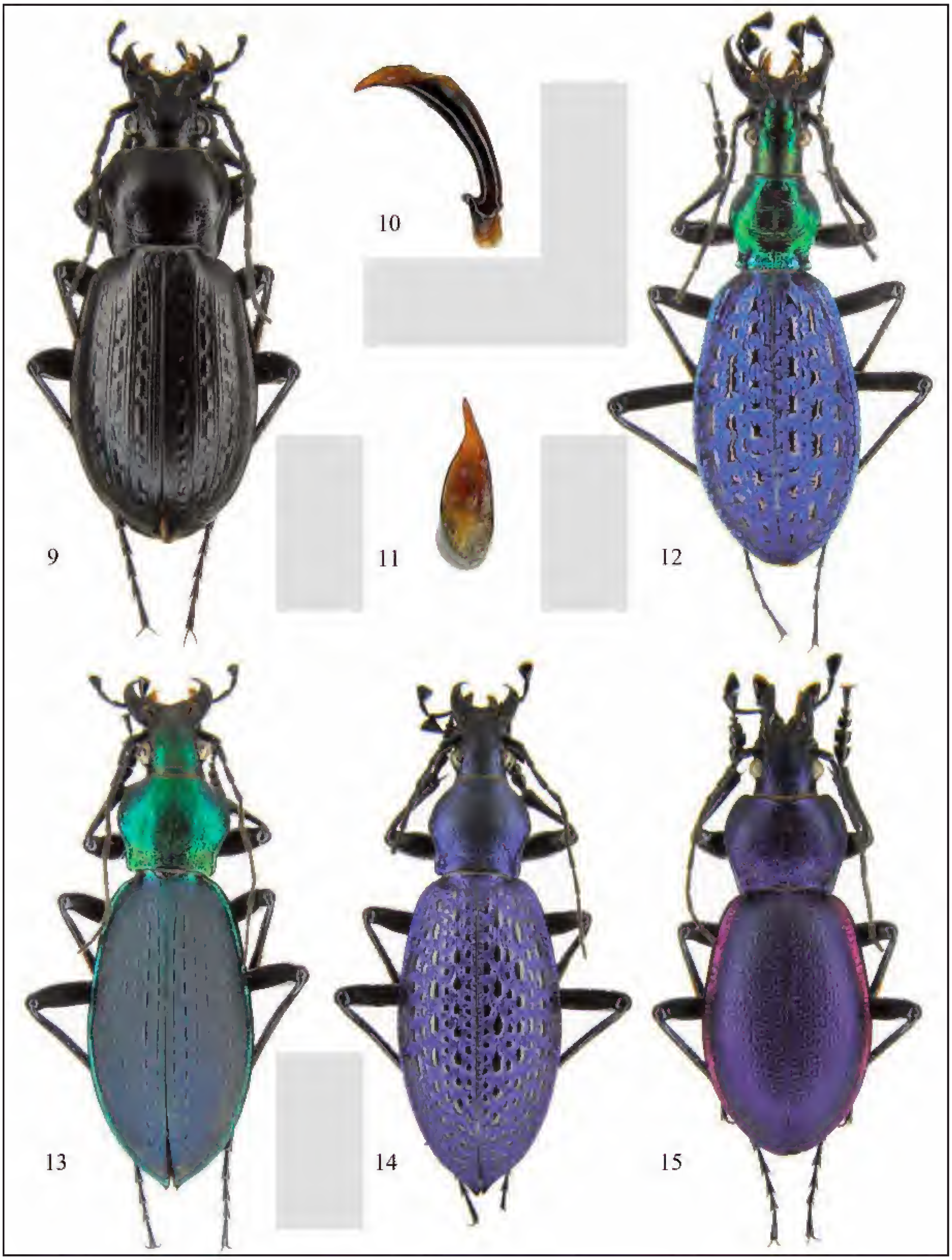

Figure 9. *Carabus* (*Carabus*) *xiuyanensis* cfr. *xiuyanensis* (21.8 mm); Figures 10, 11. Idem, aedeagus in frontal (Fig. 10) and lateral views (Fig. 11). Figure 12. *C.* (*Acoptolabrus*) *constricticollis frumielloides* (24.2 mm). Figure 13. *C.* (*Coptolabrus*) *jankowskii pseudosobaekensis* (35.6 mm). Figure 14. *C.* (*Coptolabrus*) *smaragdinus* cfr. *furumiellus* (32.7 mm). Figure 15. *C.* (*Teratocarabus*) *azrael mizunumaianus* (21 mm).

It was described on a single male specimen from Kuandian Xian area and up to now is known only by the holotype. The species seems to be very rare and endemic from Liaoning Province. The new data are very interesting and after the examination of the collected specimen we identify it as a form very close to the typical one.

Carabus (*Acoptolabrus*) *constricticollis frumielloides* Deuve, 1997 (Fig. 12)

The collected specimens of *C.* (*A.*) *constricticollis* Kraatz, 1886 are with blue elytra and green pronotum, by this very particular coloration they belong to the subspecies *furumielloides* described from Bexi Xian (Deuve, 1997) and known from several localities in the Southeast Liaoning: Fengcheng Xian, Kuandian Xian, Xinbin Xian and Huaiyin Xian (Deuve & Li, 2000b), the new locality seems to be the northernmost one. A population with light blue shades elytra lives in Xiaoduling in Jilin Province (Deuve et al., 2011).

Carabus (*Coptolabrus*) *jankowskii pseudosobaekensis* Deuve et Li, 1998 (Fig. 13)

The new locality is just in the middle between the typical locality (Benxi Xian, Mount Guanmen Shan, Liaoning) and the population from Jilin, Tonghua Xian, Xiaoduling (Deuve et al., 2011).

Carabus (*Coptolabrus*) *smaragdinus* cfr. *furumiellus* Deuve, 1994 (Fig. 14)

The specimens are with very deep blu-violet elytra and dark blue-green pronotum. They very probably belong to a transition form between *C. smaragdinus furumiellus* and *C. smaragdinus cyanelytron* Deuve et Li, 2003 described and known from Southwest Jilin Province but are closer to the first one by more elongate body and more green pronotum.

Carabus (*Teratocarabus*) *azrael mizunumaianus* Imura, 1991 (Fig. 15)

The new locality is situated more to the North West than the known localities in Liaoning Province (Benxi Xian and Xinbin Xian) (Deuve & Li, 2000b).

CONCLUSIONS

The *Carabus* fauna from Mt. Bing-La-Shan, Xifeng County, Tieling City, Liaoning Province is closely related to the *Carabus* fauna from Central South Liaoning (Benxi, Xinbin and Fengcheng).

The distribution of several species, namely: *C.* (*Teratocarabus*) *azrael mizunumaianus, C.* (*Acoptolabrus*) *constricticollis frumielloides*, and *C.* (*Coptolabrus*) *smaragdinus* cfr. *furumiellus* was enlarged to the North thanks to the present investigation. The presence of a new population of *C.* (*Carabus*) *xiuyanensis* is the most interesting result of the present study.

ACKNOWLEDGEMENTS

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Ultrasound recordings of some Orthoptera from Sardinia (Italy)

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ABSTRACT During August 2013, Ultramic 250 by Dodotronic was field-tested for application in Orthopteran acoustic biodiversity studies. The songs of four species were recorded: *Uromenus brevicollis insularis* Chopard, 1924, *Rhacocleis baccettii* Galvagni, 1976, *Svercus palmetorum palmetorum* (Krauss, 1902) and *Oecanthus dulcisonans* Gorochov, 1993. The recording campaign proved the viability of Ultramic 250 for field use and provided the opportunity to assess the presence in South-Western Sardinia of two less documented species, *Svercus palmetorum palmetorum* (Krauss, 1902) and *Oecanthus dulcisonans* Gorochov, 1993.

KEY WORDS Orthoptera; ultrasound; ecology; taxonomy.

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INTRODUCTION

The Orthoptera fauna of Sardinia is relatively well studied (A. Costa, 1882, 1883, 1884, 1885, 1886; Nadig & Nadig, 1934; Galvagni, 1976, 1978, 1990; Galvagni & Massa, 1980; Ingrisch, 1983; Schmidt & Hermann, 2000; Galvagni et al., 2007; Massa, 2010; Fontana et al., 2011) and summarized in Massa et al. (2012), with information on acoustic emission to date limited to audible frequencies (Massa et al., 2012).

A recent field expedition of the first author to SW Sardinia, Fluminimaggiore (Carbonia-Iglesias Province), resulted in the ultrasound recordings of four species herein reported to improve bioacoustics knowledge on local Orthoptera.

Study of Orthoptera acoustic emission is important for many reasons. The first and maybe most commonly pursued purpose is taxonomy, being songs useful in taxa discrimination. Biodiversity inventories can also benefit from bioacoustics studies, since many taxa that would be very elusive for direct search, are more easily tracked and identified by their song. Other aim is to investigate or better understand behavioral implications in intraspecific communication (reproductive behavior and rivalry behavior), interspecific communication and predator avoidance. We therefore focus here on ultrasound emissions of the surveyed species.

Species identification from the ultrasound recordings, a paramount requirement in biodiversity assessments, was achieved also with the support of the above mentioned audio data from Massa et al. (2012): the dissimilarity between acoustic and ultrasound recording technologies required special cautions summarized in the following section.

MATERIAL AND METHODS

All the species reported were recorded within a 15 km range from Fluminimaggiore (Carbonia-Iglesias Province, Sardinia, Italy) (Fig. 1). All the audio and ultrasound material was obtained by field recording during August 2013. Captured specimens were not recorded in constrained conditions.

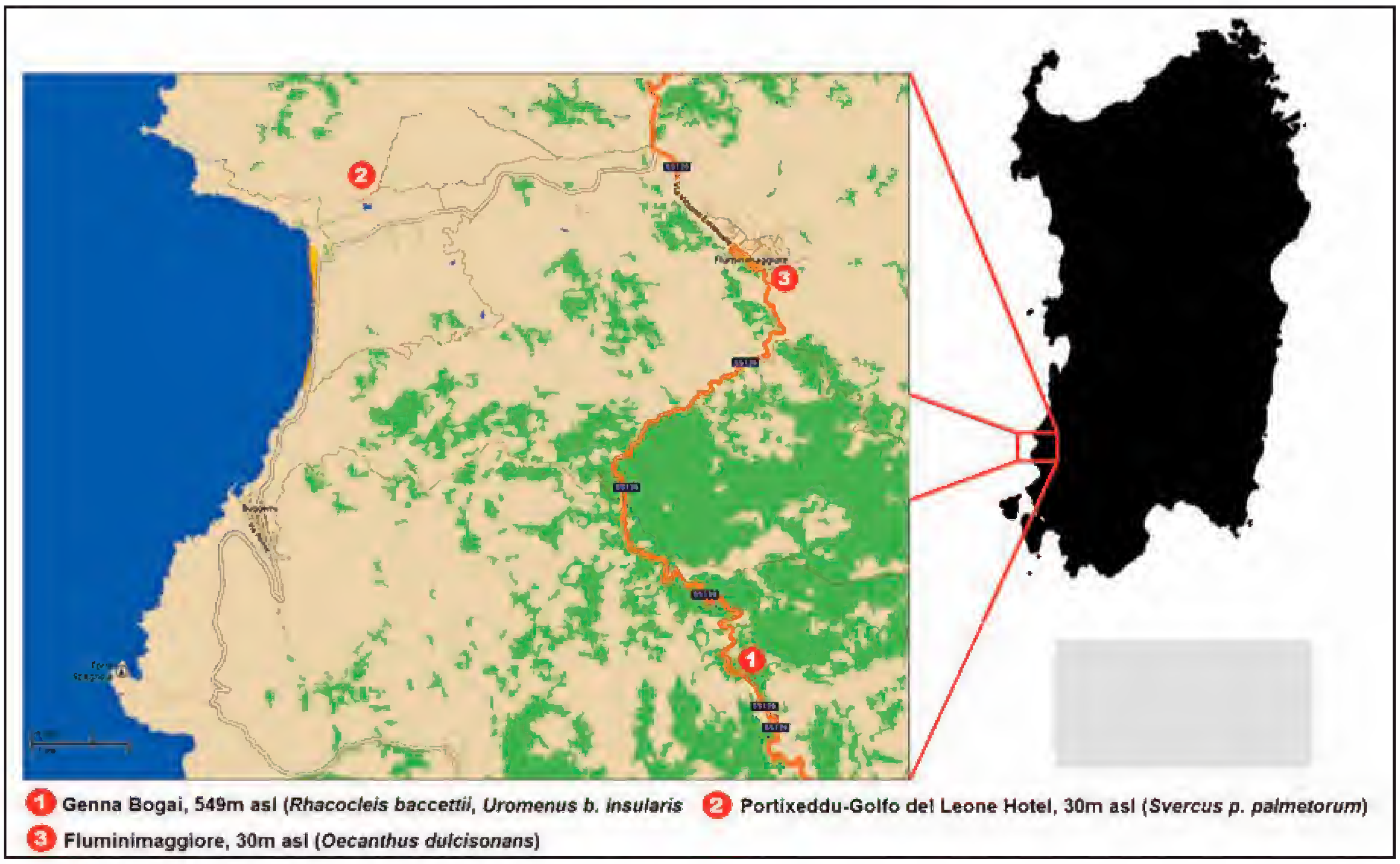


Figure 1. Recording localities: Fluminimaggiore, Carbonia-Iglesias Province, Sardinia, Italy.

Oscillograms, spectrograms and frequency analysis diagrams were produced from 250 kHz recordings by Adobe Audition 1.0 software or by the equivalent Syntrillium Cool Edit Pro version.

Subsidiary stereo, 16 bit, 96kHz sampling frequency recordings, needed to confirm species identification, were obtained by a self-built, stick mounted, stereo microphone using Panasonic WM-64 capsules (obtained from an Edirol R-09 digital recorder), connected to a Zoom H1 handheld digital Micro-SD recorder, using its built-in software.

Monophonic, 16 bit, 250kHz sampling frequency ultrasound recordings where obtained by a Dodotronic Ultramic 250 microphone, connected to an Asus Eee 1225B netbook PC, using SeaWave software by CIBRA (Pavan, 1998-2011). Ultramic is supported also by some tablet PC's (including Android-based models): the use of a Windows-based netbook was preferred for the authors' previous experience with the Windows audio analysis software, installed on the same computer used for recording. The Ultramic was set to medium gain via its special internal set of two dip switches: in about one year of field experience with this device, the authors observed that the sensitivity of the alternative settings (low gain and high gain) is respectively too low and too high to allow a correct representation of the spectral structure of Orthoptera song.

Optimal USB cable length, following several previous tests summarized in figure 2, was found to be under 1m. The short reach of the 45cm cable used for the recordings didn't allow stick-mounting, that would otherwise be ideal to take the Ultramic as near as possible to the recorded specimen, but in turn eliminated the inherent noise that may be generated by Ultramic.When coupled with Asus 1225B Netbook, inherent noise displays a 1kHz fundamental and unitary harmonics up to 12 – 15 kHz, with main audible frequency at 2kHz and secondary audible frequencies at 1kHz, 4 kHz and 7 kHz. From personal communications, the noise spectral pattern is unaltered when Ultramic is coupled with different recording platforms. The 1kHz fundamental was found to be inherent to the Ultramic, and caused by the USB polling/packet transmission on which the communications between microphone and PC (or tablet) are based, at 1000 cycles per second.

As long as the original scope of Ultramic is recording inaudible Chiropteran sounds, noise in the range of the unaided ear was deemed irrelevant.

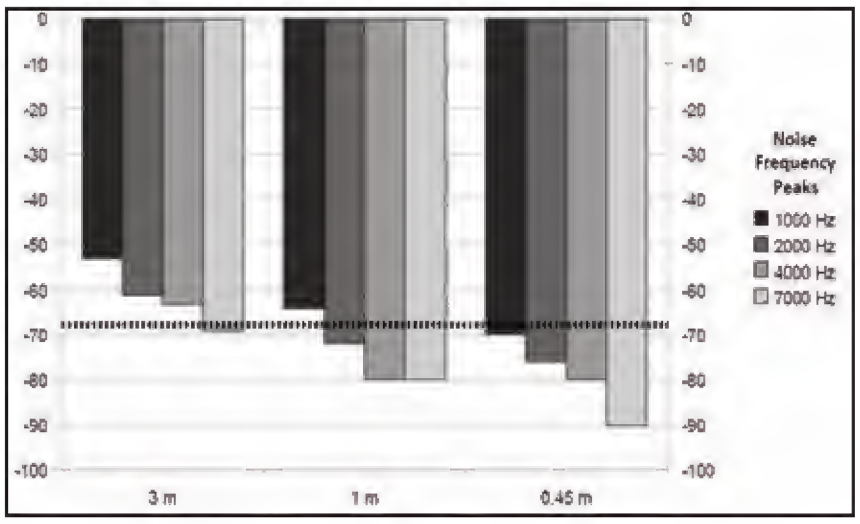


Figure 2. Effect of cable length in the mitigation of Ultramic 250 inherent noise. Vertical axis: sound pressure (dB), horizontal axis: USB cable length (m), dashed line: typical Ultramic 250 noise floor under ideal field recording conditions (-68 dB ref full scale level).

But when recording in the audible range, the whistle at 2kHz becomes definitely undesirable, and the authors investigated how the USB cable length affects inherent noise, testing whether ferrite cores along the cable can mitigate it. The tests allowed to conclude that:

1. Ferrite cores do not mitigate the noise, that originates in the very same device used for recording.

2. USB cable length of less than 1m eliminates the noise bringing it below the level of the background noise present in any field recording.

It should be noted that the recordings obtained by using the Ultramic 250, a device specifically designed to collect ultrasonic frequencies, may not be suitable for specific song pattern recognition by memory and unaided ear, and thus may require sonogram and spectrogram comparisons with existing audio-only recordings, a necessity observed for example in the case of *Rhacocleis baccettii* Galvagni, 1976. Two potential problems, lack of published ultrasound recordings and lack of audible components in the Ultramic recording, may complicate such a comparison. Indeed, the greatest majority of current scientific and popularization works about bioacoustics investigated only the acoustic range: available sonograms, spectrograms, frequency analyses and descriptions almost invariably refer to the audible frequency components.

When field-recording with Ultramic, it's therefore advisable to adopt one or more of the following cautions:

• Visually / photographically identify the singing specimen.

• Collect and identify a specimen.

• Record the same specimen both by Ultramic and by audio microphones, capable of generating audio files whose sonograms, spectrograms, frequency analyses are easily comparable with existing literature.

Subsidiary audio recordings should possibly be taken at 96kHz sampling frequency, so that (depending on the dynamic response of the audio microphone capsules) low ultrasonic frequency may get recorded, allowing an easier bridging of the gap between audio and ultrasound recordings. The first author performed successful simultaneous recordings from the USB and the audio ports of a portable computer, with audio microphone and Ultramic coaxially mounted on the same self-built stick and handle assembly, the drawback of this set being the impossibility to have both microphones at optimal range from the subject without saturating one of the recordings, and the noise induced by the length of the USB cable required for stick mounting. So, in the case of simultaneous recordings, although the handling of two microphones may prove feasible for a single operator, the authors advise to operate in pairs by using two separate portable digital recorders (one of them, obviously, should be compatible with Ultramic, such as a portable PC or one of the supported tablet PC's).

Whether or not the song is audible to the unaided ear, audible components may not be reproduced in the Ultramic recording, depending on hardware gain settings, distance from the subject, song structure.

In particular, it's quite commonplace for the Orthopterans with the smallest stridulatory apparatus, or the highest repetition frequencies, to reach well into the ultrasonic domain, so that it's a routine practice to locate them with the aid of a bat detector, as reported for example by Fontana et al. (2002). For those species, sound pressure at ultrasonic frequencies may be way higher than in the audible range, with the practical consequence that Ultramic 250 may get saturated by the ultrasounds well before reaching the distance at which the audible components may get recorded. Thus, the resulting recording may be both inaudible and unfamiliar, up to the point of being useless without supporting materials such as visual identification, specimen collection or simultaneous audio recording.

Another distinction between audio and ultrasonic recordings stems from the higher sampling frequencies of the latter, that (even for the very same sound

source) may result in a different shape of the sonogram, especially when the emission of the louder, dominating ultrasonic elements is not perfectly synchronous with the emission of the potentially audible components. As a consequence, species recognition by listening of an Ultramic recording may prove difficult even in the case of well-known, common species' songs. All these problems were present in the case of *R. baccettii*, a low-Q species delivering a high-pitched call dominated by ultrasounds, whose spectrogram doesn't provide relevant distinctive features and whose Ultramic recording, barely audible, didn't bear any immediate resemblance to the audio recording available for comparison.

To overcome the problem, some saturated (above zero dB) Ultramic recordings were made on purpose, to ease recognition by ear and comparison with available reference material: although counter-intuitive, this practice is in fact very useful. In all the cases where ultrasonic pressure outweighs audible frequencies' pressure, after taking unsaturated recordings one may decide to get as close to the subject as needed for grasping the audible components, even though it means making the recording unusable for analytical purposes. Just for the sake of ease of recognition, saturation may be disregarded as long as it occurs in the inaudible range. Obviously, only regular, unsaturated recordings may be used for analyses, while the saturated recording may eventually being low-pass filtered at 21 kHz, and amplified as needed. The preceding practical suggestions outline the protocol illustrated in figure 3.

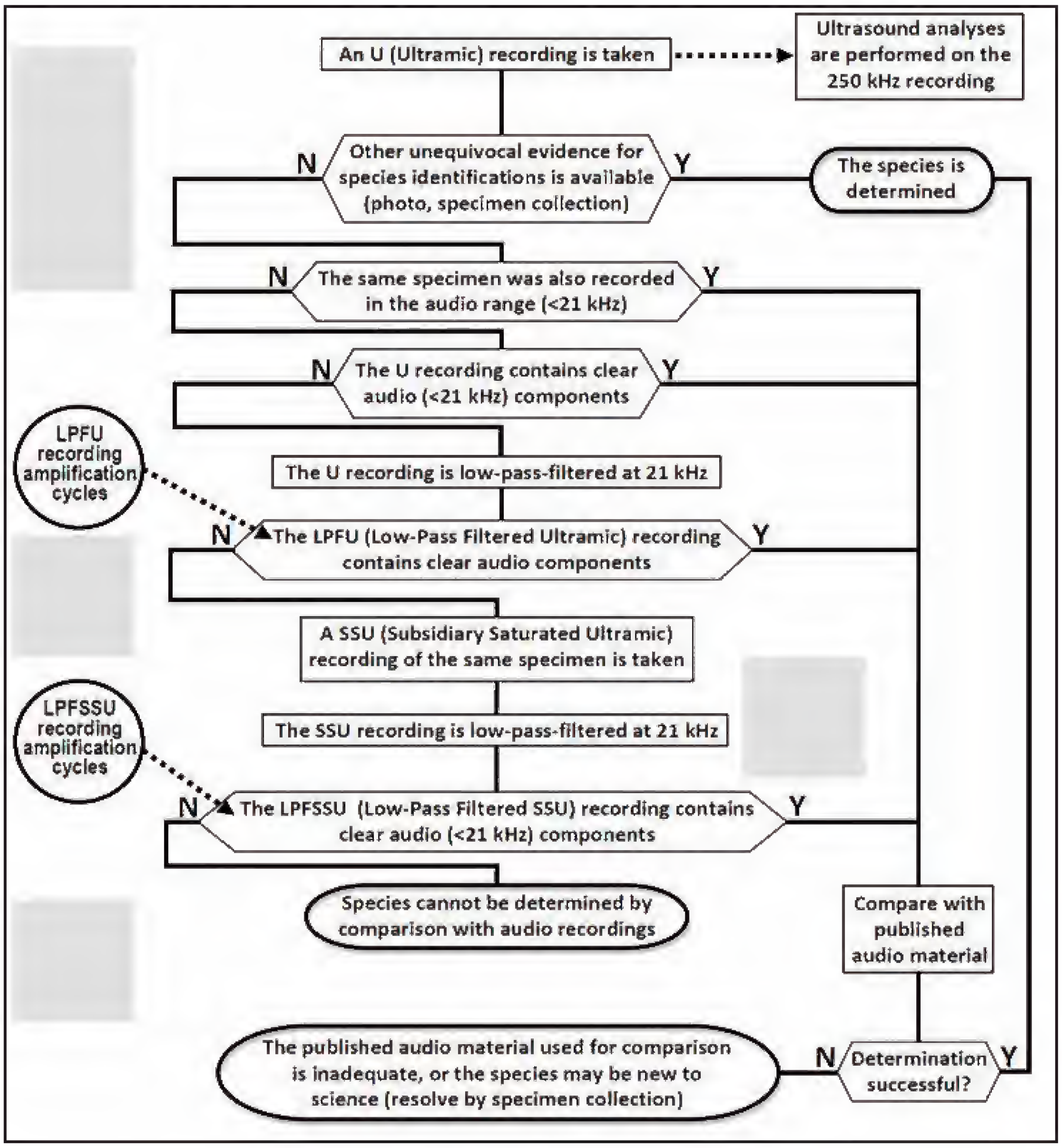


Figure 3. Suggested protocol to allow species identification form Ultramic recordings (flow chart).

DISCUSSION

Terminology on Orthoptera song description may not always be able to convey the sometimes complex structure of sound emission. The song of all the taxa here presented is described in Massa et al. (2012) for their audible range. The authors therefore focused on ultrasounds, frequency analysis and their description. A useful distinction can be made between "high-Q" and "low-Q" spectrum type (Elsner & Popov, 1978; Montealegre & Morris, 1999). High-Q sound results in one or more (e.g. Gryllidae) isolated peaks of frequency, clearly distinguishable from the rest of the frequency emission. On the other hand, "band" or "low-Q" of frequency sound gives a wide bandwidth spectrogram, in which sometimes is possible to distinguish spectral subpeaks (see Table 1).

For what concerns audible sound description we use terminology from Buzzetti & Barrientos (2011), Moore (1989) and Ragge & Reynolds (1998):

- Chirp (or phonatome, syllable): a short, clearly definable sound, produced by a complete opening and closing movements of the tegmina (or upward and downward movements of hind legs).
- Zip: a series of pulses resulting in a short buzz, usually shorter than a chirp.
- Trill: a long series of pulses, in which chirps cannot be recognized.
- Echeme: most basic and simple assemble of syllables.

List of the recorded species

Uromenus brevicollis insularis Chopard, 1923

Examined material. Italy, Sardinia, Genna Bogai (Carbonia-Iglesias Province), N 39° 22' 25.428", E 8° 29' 50.352", 549m asl, 29.VIII.2013, 1 male.

Distribution. *Uromenus brevicollis insularis* is distributed and locally common in Sardinia and Corsica (its type locality).

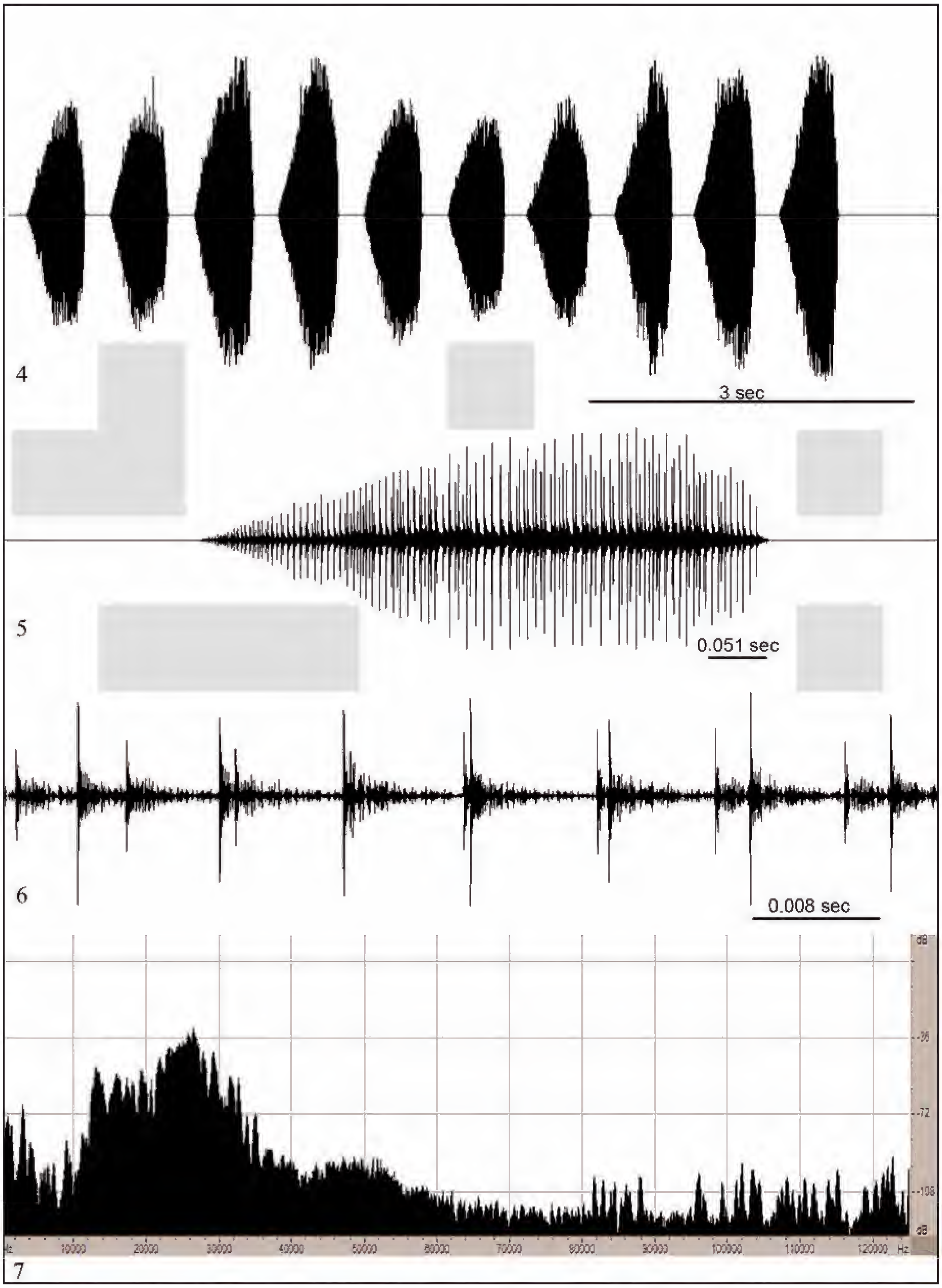
Remarks. This calling song was recorded with air temperatures in the range of 18°C, around midnight, at the Genna Bogai pass. The song could be just faintly perceived by the unaided ear, but proved very easy to locate by the earphones connected to the digital audio recorder. Ultrasound recording didn't meet any particular difficulty, apart the usual tendency to saturate when approaching to the specimen. The male calling song (Fig. 4) consists of a sequence of chirps that are indeed closing hemisyllables. Each hemisyllable (Fig. 5) lasts for about 250-350ms and is composed of about 75-80 tooth-impacts (Fig. 6) (Massa et al., 2012). Comparison between frequency spectrum analysis (Fig. 7) and time-frequency spectrogram (Fig. 8), shows that most energy is emitted from 10 to 40 kHz, with weaker extension to less than 60 kHz. From 10 kHz, the energy rapidly increases to the first maximum peak at 13.45 kHz. A minor energy area, with lower peaks at 16.17, 18.52 and 19.37 kHz, is present between 15 and 21.35 kHz. Then the energy increases to the power peak at a frequency of 26.7 kHz. From here, the energy emitted decreases to 41.25 kHz, with peaks at 29.26, 31.86, 32.83, 33.87 and 35 kHz. A second band of low energy emission is from 41.25 to 58.68 kHz, with a peak at 43.7 kHz

U. brevicollis insularis emits a very wide energy band, reaching ultrasonic frequency, that results in a mostly ultrasonic bandwidth with a ultrasonic range (26.7 kHz) peak.

The song of *U. brevicollis insularis* recorded and here presented, was emitted simultaneously

Species	Principal carrier frequency in kHz	Spectrum type	Most relevant energy emission	Singing rate	Sound unit
Uromenus brevicollis insularis	12 to 41	Low-Q	Sonic	1/sec	Chirp (closing hemisyllable)
Rhacocleis baccettii	28 to 77	Low-Q	Ultrasonic	3-4/sec	Zip
Svercus palmetorum palmetorum	6-12-18-25-(32)	High-Q	Sonic	7-12/sec	Echeme
Oecanthus dulcisonans	3.5-7-10.5	High-Q	Sonic	40/sec	Syllable

Table 1. Main distinctive parameters in the song of the recorded species.



Figures 4–7. Song of *Uromenus brevicollis insularis*. Figure 4: calling song. Figure 5: syllable (closing hemisyllable). Figure 6: tooth-strokes. Figure 7: frequency analysis, FFT size 8192 bytes.

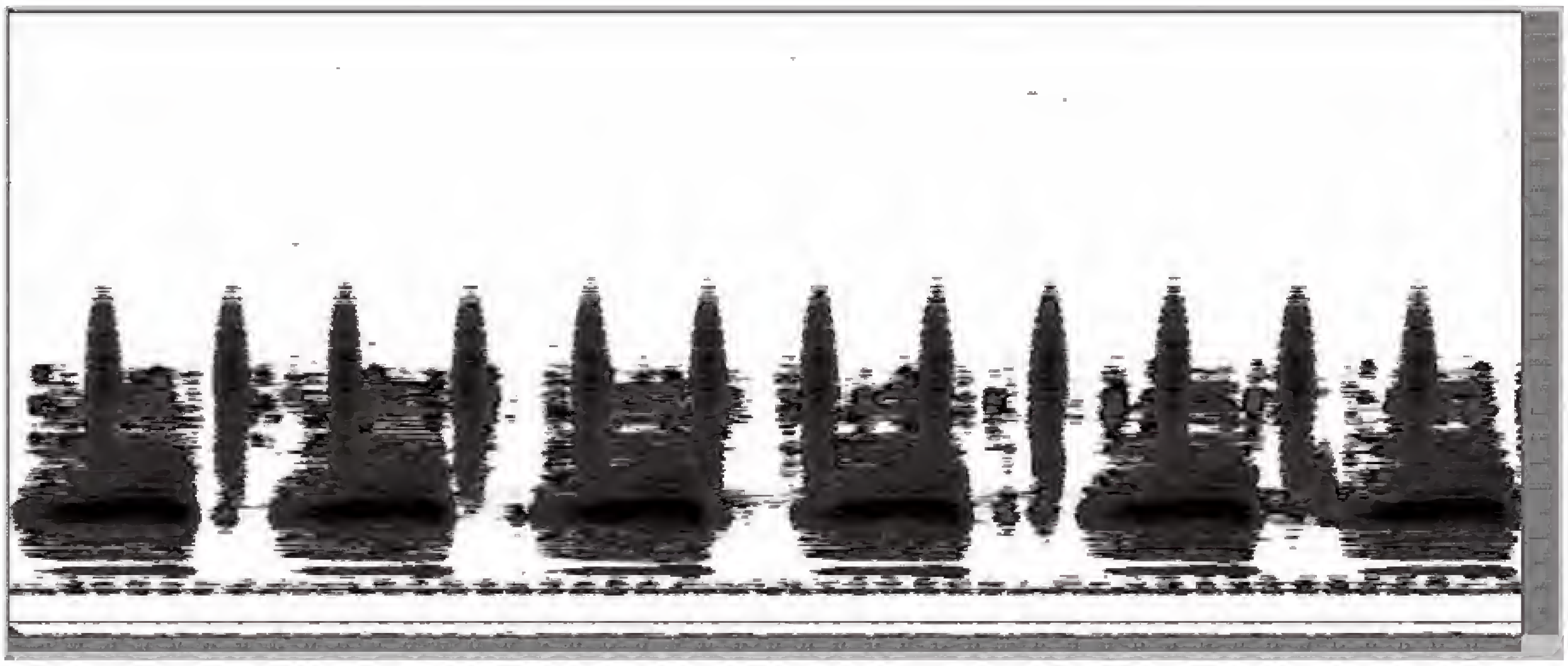


Figure 8. Time-frequency spectrogram of the simultaneous songs of *Uromenus brevicollis insularis* and *Rhacocleis baccettii*.

(Fig. 8) with another calling song by *Rhacocleis baccettii* Galvagni, 1976. A very careful analysis of both the graphs about frequency analysis and temporal frequency spectrum was necessary to discriminate the energy emission of the two taxa. Nevertheless it has become clear (see *R. baccettii* discussion) that these two species share the same sound landscape, with little interference.

Rhacocleis baccettii Galvagni, 1976

Examined material. Italy, Sardinia, Genna Bogai (Carbonia-Iglesias Province), N 39° 22' 25.428", E 8° 29' 50.352", 549m asl., 29.VIII.2013, 1 male.

Distribution. Endemic of Sardinia (type locality: Monte Ferru, Oristano), is known for whole Sardinia and is the commonest species of the genus in this region.

Remarks. The song of this species varies among populations from different localities (Massa et al., 2012). The song here presented is very similar to what is presented in Massa et al. (2012) to be the typical song of *R. baccettii*. The calling song of *R. baccettii* (Fig. 9) is made of short zip repeated in sequence at a rate of 3-4/sec. Each zip (Fig. 10) consists of 30-40, up to 50 syllables of different intensity. Frequency spectrum analysis (Fig. 11) shows a low-Q band of energy emission between 28 and 77 kHz, with highest frequency at 50-51 kHz. The song of this species is therefore mostly ultrasonic.

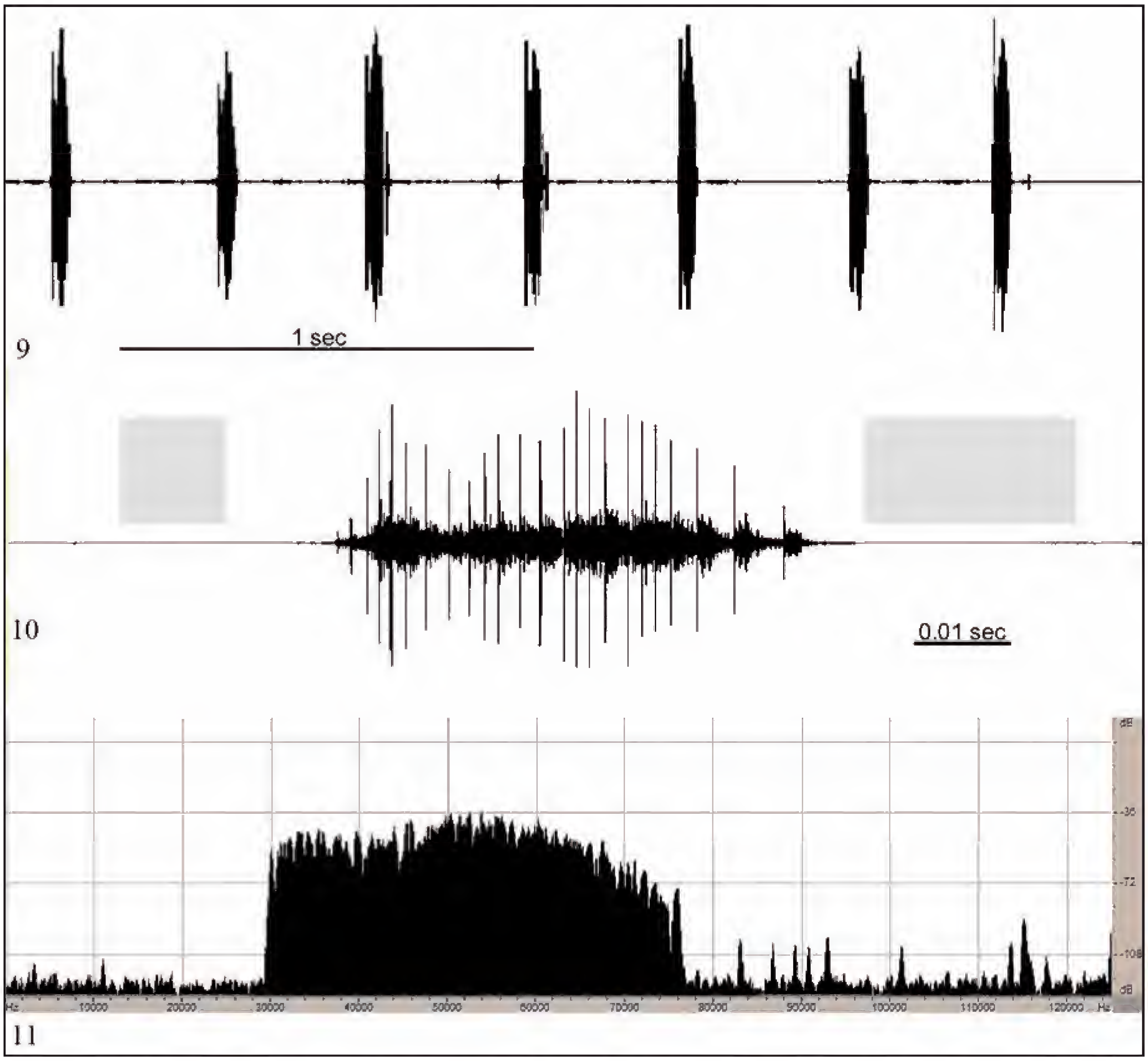
Figure 8 presents the two simultaneous songs of *U. brevicollis insularis* and *R. baccettii*, clearly showing striking differences between the sound emitted by the two species. While *Uromenus* emits a long chirp mostly sonic with main peak at 26 kHz, *Rhacocleis* sings with very short buzz that are mostly ultrasonic. The sound space is therefore shared, with no interference since the sound structure, i.e. temporal parameters and frequency emitted, is completely different in the two species. Such differences are known to be useful in specific mate recognition for sympatric or syntopic species (Zefa et al., 2012), even in "cocktail party" conditions (Siegert et al., 2013).

Svercus palmetorum palmetorum (Krauss, 1902)

Examined material. Italy, Sardinia, Fluminimaggiore (Carbonia-Iglesias Province), N 39° 26' 53.232" E 8° 25' 30.18", 30m asl, 8 August 2013, 1 male.

Distribution. *Svercus palmetorum* is distributed in North Africa and South West Asia, plus Italy, Spain, Canary Is., Baleares Is., Corsica, Malta and Cyprus. In Italy is known for few localities in Sardinia, Sicily and Calabria.

Remarks. The song (Fig. 12) is composed by sharp trills that can be continuous or interrupted by a very short pause. Echemes (Figs. 13–14) consist of groups of 7 to 9 syllables lasting on average 0.05 s in which the starting syllables are, each syllable lasting on average 5 ms.

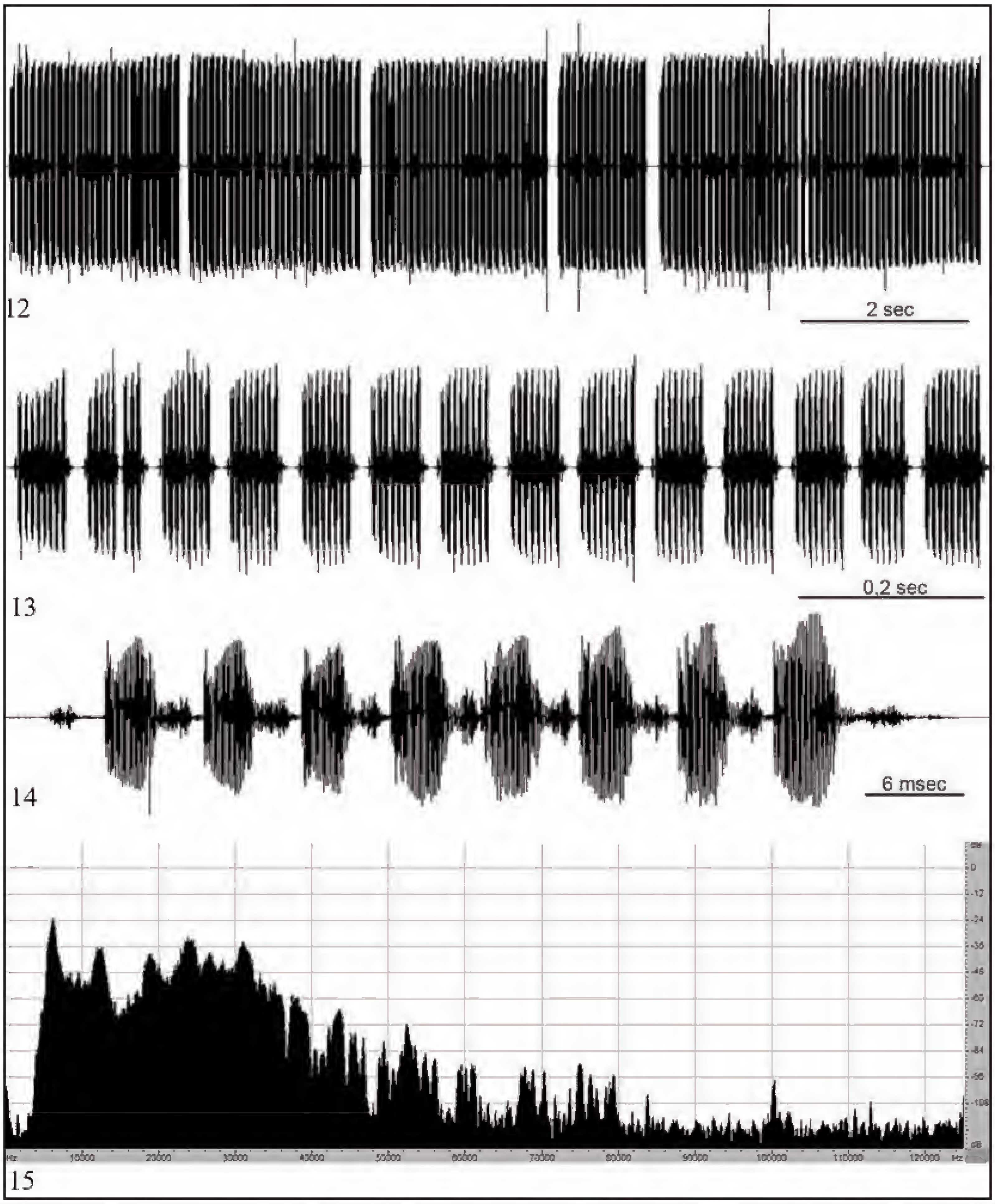


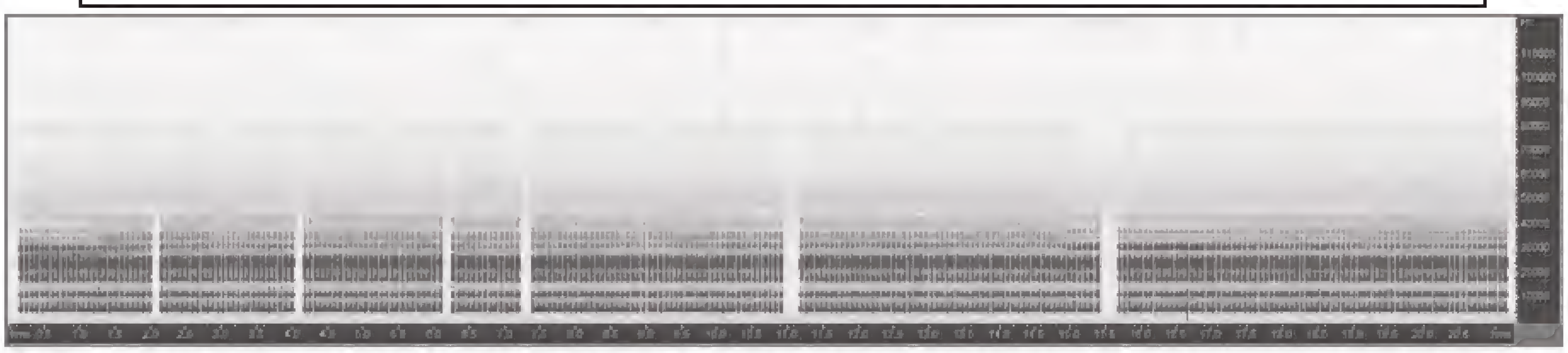
Figures 9–11. Song of *Rhacocleis baccettii*. Figure 9: calling song. Figure 10: sound unit. Figure 11: frequency analysis, FFT size 8192 bytes.

Average silent time between echemes is 0.02 s.

Each trill may include bouts of 8–20 echemes, or may be continuous (>100 echemes without interruption). Song bouts are separated by intervals that may last 0.10 s–0.30 s once the song is initiated, or up to several seconds in the initial or final phases of the song. 250 kHz ultrasound recordings, besides displaying the same pattern described above, allowed a deeper high frequency analysis showing a very elaborated spectral pattern. The strong harmonic structure of the song is revealed by a close up of the spectral analysis in a window between -12 db and -90 db, and for frequencies up to 85 kHz. The pattern of regularly spaced harmonic frequencies can be made out quite clearly. Opening hemisyllable is weaker than closing one, emitting very few energy at a frequency of about 25 kHz. Frequency analysis of closing hemisyllable (Fig. 15) reveals the fundamental at 6.317 kHz, and three harmonics at 12.2 kHz, the weakest at 18.82 kHz and the last at 25.69 kHz. In the first part of each closing hemisyllable an upper harmonic is present at about 32.5 kHz, lasting for 1 msec.

Given the peculiarity of this species, we present here some morphological characters (Figs. 17–19) and the original description (Fig. 18). In the figures are clearly evident the diagnostic characters of this





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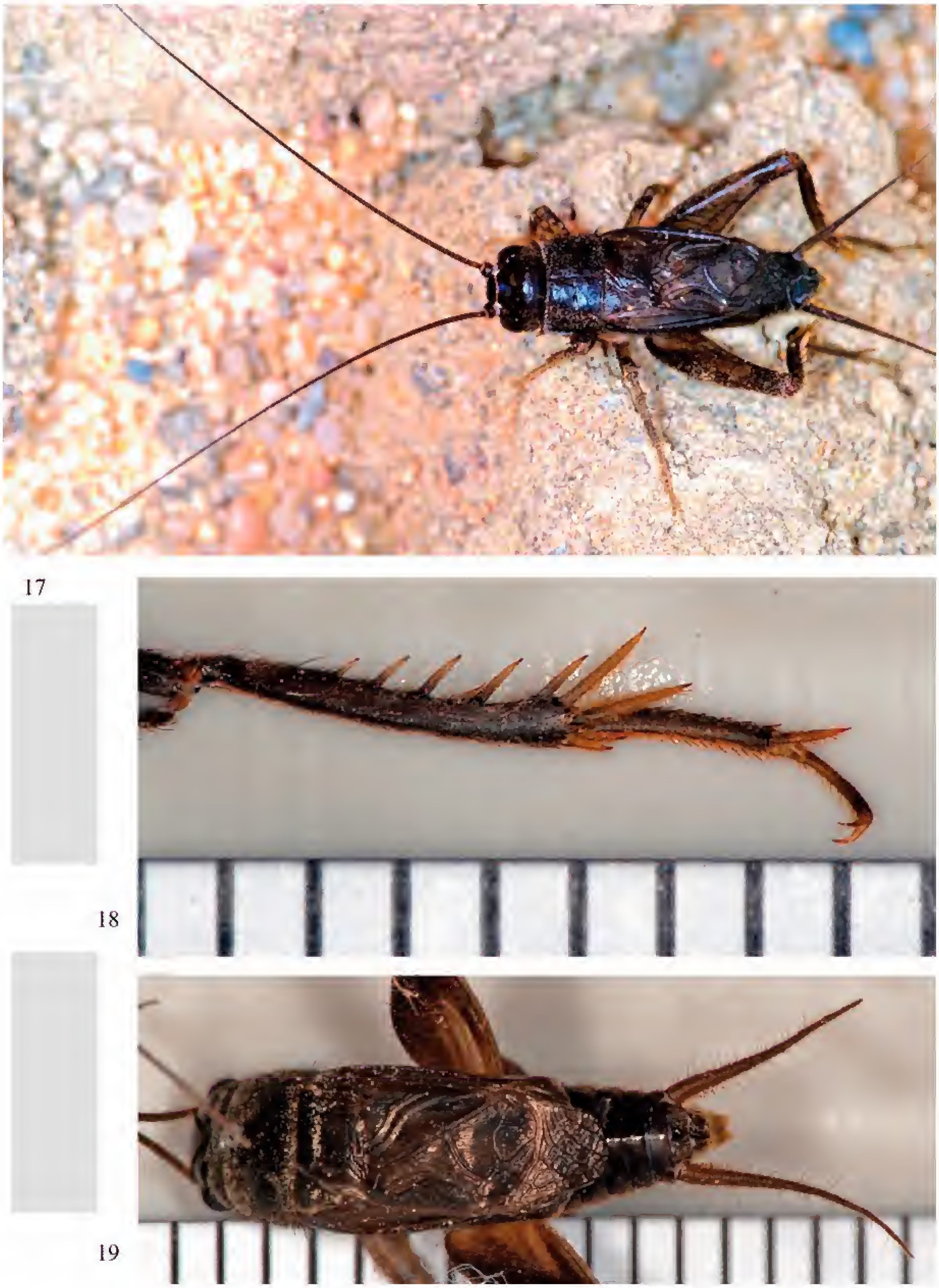
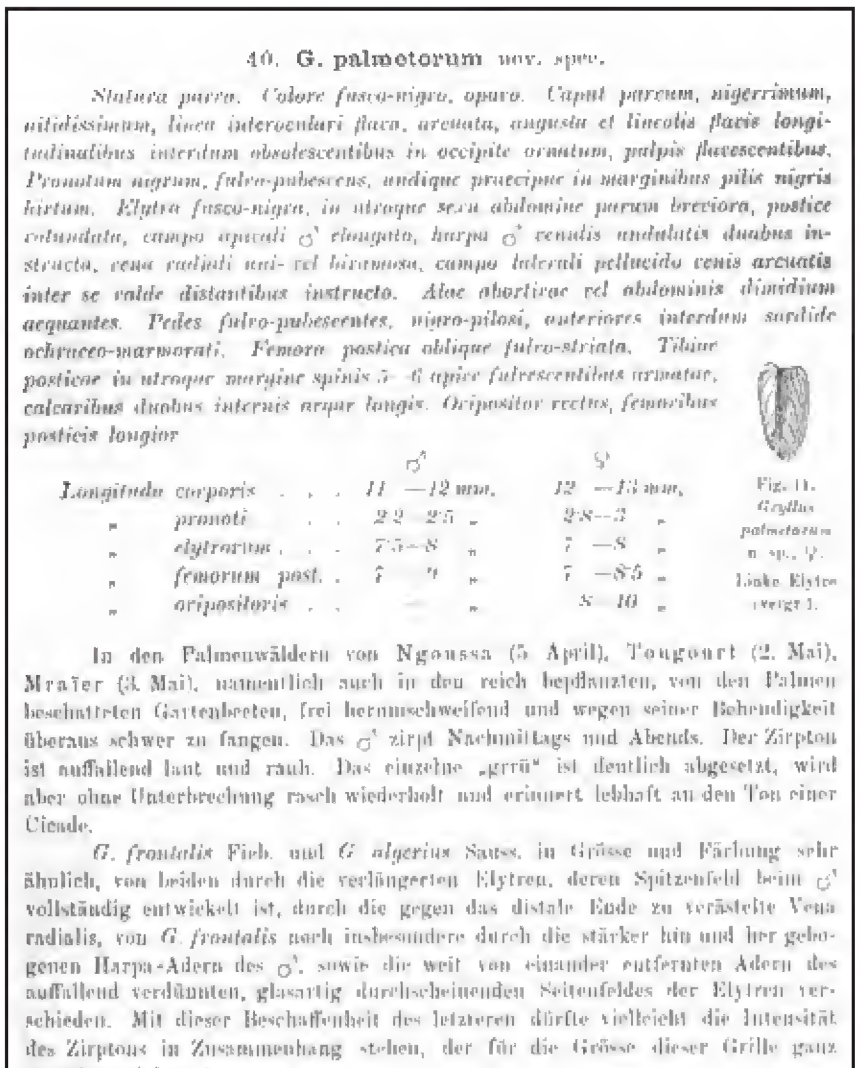
Figures 12–15. Song of *Svercus palmetorum palmetorum*. Figures 12–13: calling song. Figure 14: sound unit. Figure 15: frequency analysis, FFT size 8192 bytes. Figure 16. Spectrogram of the 250kHz audio sample from *S. palmetorum palmetorum*, "Golfo del Leone", Portixeddu, 8 August 2013, 23°C.



Figures 17–19. *Svercus palmetorum palmetorum*. Figure 17: living male from Fluminimaggiore. Figure 18: male hind tibia, scale 1 mm. Figure 19: male tegmina, scale 1 mm.



40. **G. palmetorum** nov. spec.

Statura parva. Colore fusco-nigro, opaco. Caput parvum, nigerrimum, nitidissimum, linea interoculari flava, arcuata, angusta et lineolis flavis longitudinalibus interdum obsolescentibus in occipite ornatum, palpis flavescentibus. Pronotum nigrum, fulvo-pubescens, undique praecipue in marginibus pilis nigris hirtum. Elytra fusco-nigra, in utroque sexu abdomine parum breviora, postice rotundata, campo apicali ♂ elongato, harpa ♂ venulis undulatis duabus instructa, vena radiali uni- vel biramosa, campo laterali pellucido venis arcuatis inter se valde distantibus instructo. Alae abortivae vel abdominis dimidium aequantes. Pedes fulvo-pubescentes, nigro-pilosi, anteriores interdum sordide ochraceo-marmorati. Femora postica oblique fulvo-striata. Tibiae posticae in utroque margine spinis 5–6 apice fulvescentibus armatae, calcaribus duobus internis aeque longis. Ovipositor rectus, femoribus posticis longior

		♂	♀
Longitudo	*corporis*	11 —12 mm.	12 —13 mm.
„	*pronoti*	2·2—2·5 „	2·8—3 „
„	*elytrorum*	7·5—8 „	7 —8 „
„	*femorum post.*	7 —? „	7 —8·5 „
„	*ovipositoris*	— „	8—10 „

Fig. 11. *Gryllus palmetorum* n. sp., ♀. Linke Elytre (vergr.).

In den Palmenwäldern von Ngoussa (5. April), Tougourt (2. Mai), Mraïer (3. Mai), namentlich auch in den reich bepflanzten, von den Palmen beschatteten Gartenbeeten, frei herumschweifend und wegen seiner Behendigkeit überaus schwer zu fangen. Das ♂ zirpt Nachmittags und Abends. Der Zirpton ist auffallend laut und rauh. Das einzelne „grrü" ist deutlich abgesetzt, wird aber ohne Unterbrechung rasch wiederholt und erinnert lebhaft an den Ton einer Cicade.

G. frontalis Fieb. und *G. algerius* Sauss. in Grösse und Färbung sehr ähnlich, von beiden durch die verlängerten Elytren, deren Spitzenfeld beim ♂ vollständig entwickelt ist, durch die gegen das distale Ende zu verästelte Vena radialis, von *G. frontalis* noch insbesondere durch die stärker hin und her gebogenen Harpa-Adern des ♂, sowie die weit von einander entfernten Adern des auffallend verdünnten, glasartig durchscheinenden Seitenfeldes der Elytren verschieden. Mit dieser Beschaffenheit des letzteren dürfte vielleicht die Intensität des Zirptons in Zusammenhang stehen, der für die Grösse dieser Grille ganz ausnehmend laut ist.

Figure 20. *Svercus palmetorum* original description from Krauss (1902).

taxon, i.e. hind tibia spinulation, wing venation pattern and transverse line on the head.

Oecanthus dulcisonans Gorochov, 1993

Examined material. Italy, Sardinia, Fluminimaggiore (Carbonia-Iglesias Province), N 39°26' 53.232" E 8° 25' 30.18", 30m asl, 29 August 2013, 1 male.

Distribution. *Oecanthus dulcisonans* is known for Canary Is., Spain, Italy and Middle East. Very few localities are known for Sardinia. The presence of this species in Sardinia was ascertained by Schmidt & Herrmann (2000). It is still unreported in the online version of the Fauna d'Italia checklist, but is reported in Massa et al. (2012) with the comment "a few records from Sardinia, central Italy and Sicily, the status in Italy is unclear".

In fact, until Gorochov (1993) description, *O. dulcisonans* wasn't separated from *O. pellucens pellucens* (Scopoli, 1763), so particular care was put in the unequivocal identification of a specimen from the locality where audio recording (both at 96 kHz and at 250 kHz) took place, namely the town of Fluminimaggiore (Carbonia-Iglesias province) under the bridge of Riu Billittu, at an elevation of 80m. Temperature at the moment of recording was 22.1°C. For a quick identification of *O. dulcisonans*, the acoustic and morphological guidelines by Cordero et al. (2009) where applied to the audio sample and to the collected specimen (Figs. 21, 22). The morphological identification didn't pose any doubt, even though the Sardinian specimen, with a tegminal length of 13 mm and a femural length of 8 mm, although obviously larger than *O. pellucens pellucens*, fell slightly below the measurements provided by Cordero et al. (2009) for tegmen length (*dulcisonans* = 14.01 ± 0.26; *pellucens* = 10.80 ± 0.14) (t_{15} = 12.05; $P < 0.0001$) and femur length (*dulcisonans* = 8.60 ± 0.14; *pellucens* = 7.60 ± 0.17) (t_{14}= 4.06; $P < 0.001$) for specimens from Spain and Tunisia.

Remarks. The calling song (Fig. 23) of *O. dulcisonans* consists of a melodious trill emitted almost continuously. Trills (Fig. 24) consist of syllables emitted at average rate of 40/sec.

Frequency analysis (Fig. 25) shows high-Q pitched emission of energy. Dominant frequency is at 3.295 kHz, with harmonics at 6.286, 9.216 and 12.39 kHz, being therefore strictly in the audio range. Enhanced contrast in time-frequency spectrogram (Fig. 26) show very weak harmonics above 13 kHz.

The song, although somehow different from the data in Cordero et al. (2009) and in Massa et al. (2012), remains clearly discernible from the repetitive but less continuous echemes in concurrent songs by *O. pellucens pellucens*, also living in the same area although not in the same environment. Direct observation of the first author confirmed that *O. pellucens pellucens* sings preferentially from trees while *O. dulcisonans* seems to prefer high grass such as the vegetation growing along small streams.

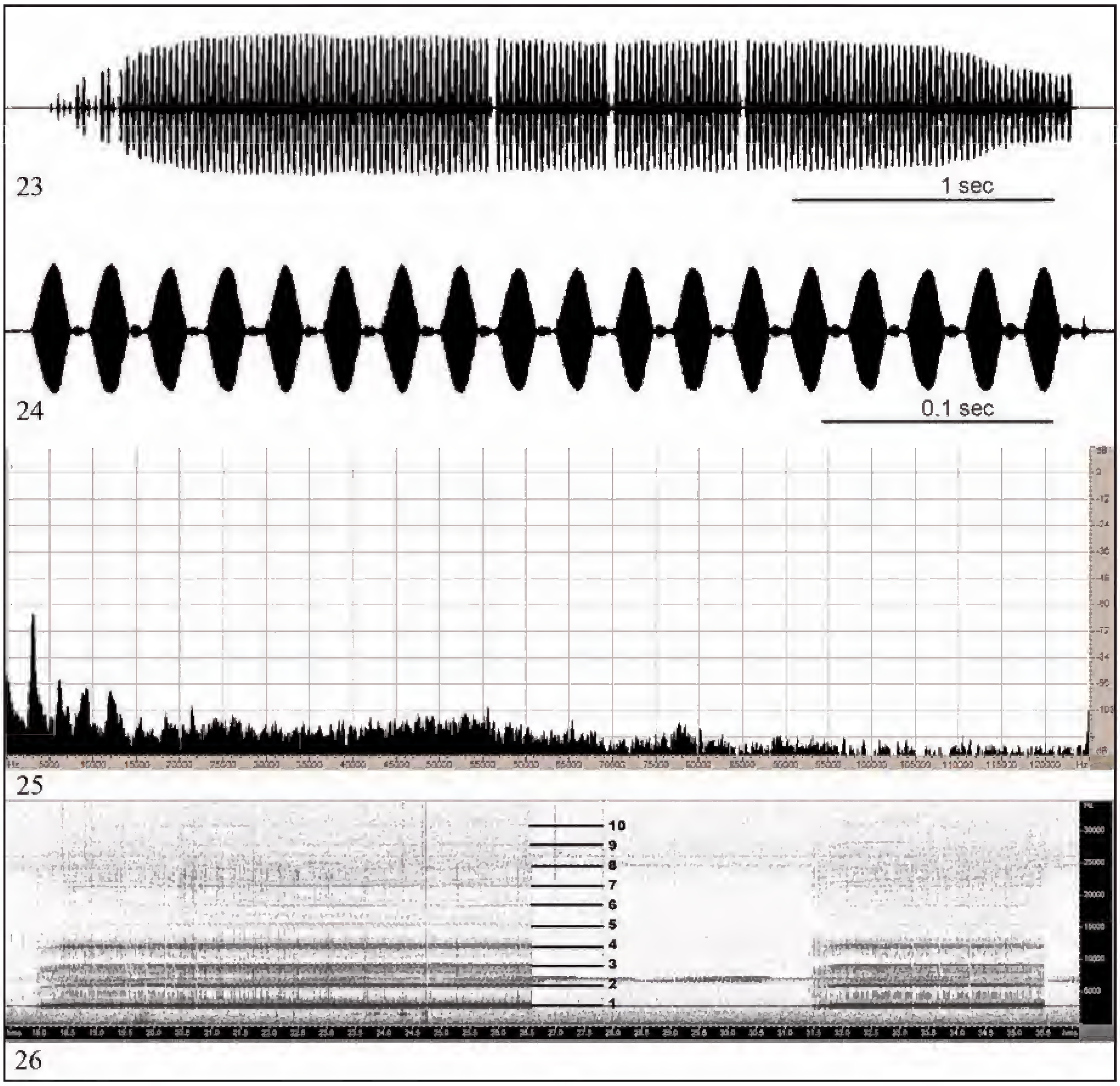
CONCLUSIONS

Ultrasound songs of four Orthoptera Ensifera from Sardinia have been recorded. Microphones with ultrasonic threshold, such as Ultramic 250 by Dodotronic, proved to be an invaluable device to investigate the ultrasonic components of Orthopteran songs. Some limitations addressed herein do not af-

Figure 21. Comparison between the *Oecanthus dulcisonans* from Fluminimaggiore (left) and the guideline illustrations from Cordero et al., 2009 (right), p = *O. p. pellucens*, d = *O. dulcisonans*. Figure 22. Living male from Fluminimaggiore.

fect its high potential as a scientific tool for field research in Orthopteran bioacoustics, in particular if the protocol outlined in the introduction is adopted. Ultramic peculiar features may require specimen collection or subsidiary audio recordings to make it an useful tool for species identification on acoustic evidence. Of the taxa recorded, the only with dominant ultrasonic emission is *R. baccettii*. *U. brevicollis insularis* and *S. palmetorum palmetorum* emit both in audio and ultrasound range, while *O. dulcisonans* appears to emit almost only in the audio range.

The presence of *S. palmetorum palmetorum*, of which to date very few data were available, is confirmed in Sardinia by audio recordings and specimens. *O. dulcisonans* is also confirmed in Sardinia for new localities. Within the limits of a clearly recognizable, more or less continuous stridulation, the song appears more variable than previously reported for the species, in particular for its main audible frequency. Also specimen size variability appears to be higher than previously reported, with a slightly smaller biometry for the Sardinian specimen. The ultrasonic components of *O. dulcisonans* calling



Figures 23–25. Song of *Oecanthus dulcisonans*. Figure 23: calling song. Figure 24: sound unit. Figure 25: frequency analysis, FFT size 8192 bytes. Figure 26. Zoom-in up to 35kHz from the 250 kHz spectrogram of *Oecanthus dulcisonans* song, displaying a main audible frequency of around 3200Hz, Fluminimaggiore, 29 August 2013, numbers show the approximate location of the first ten unitary harmonics.

song do not seem particularly relevant. Nevertheless the weak harmonics above 13 kHz of this species could have some role, the significance of which should be investigated within the frame of heterospecific behavior, though in the same genus. Bioacoustics is here confirmed to be valuable in biodiversity assessment and taxonomic distinction. Sound analysis deeper than simple sonogram illustration, allow to gain more details for sound description, taxonomic discussion and ethological observations.

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Analysis of the vascular flora of four satellite islets of the Egadi Archipelago (W Sicily), with some notes on their vegetation and fauna

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ABSTRACT

This paper represents the first contribution on the vascular flora of the stack named Faraglione di Levanzo and of three satellite islets of Favignana, i.e. Prèveto, Galeotta and a stack located at Cala Rotonda. A sketch of their vegetation pattern is also provided, as well as a list of all the terrestrial fauna, with some more detailed information on the vertebrates. The finding of some bones of *Mustela nivalis* Linnaeus, 1758 is the first record for the whole archipelago and deserves further investigations. The floristic data have been used in order to analyze life-form and chorological spectra and to assess species-area relationship, the peculiarity of local plant assemblages, the occurrence of islet specialists, the risk of alien plants invasion and the refugium role played by the islets. The significant differences among the check-lists compiled by the two different couples of authors during their own visits to Prèveto and Galeotta underline the need of planning regular and standardized field investigations in order to avoid an overestimation of local species turnover rates.

KEY WORDS Ellenberg bioindicator values; Life-form spectra; Mediterranean Sea; Unbalanced biota.

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INTRODUCTION

The aims of the paper

Egadi Islands are located in the province of Trapani and form the westernmost archipelago of Sicily. The whole archipelago includes three main islands, i.e. Favignana, Marettimo and Levanzo, and almost ten islets and stacks, mostly dispersed in the sea near the coast of Trapani or between Trapani and Levanzo. In this paper we present the results of a five-years-long investigation carried out by two different teams, mainly focused on the vascular flora of four of these tiny islets, i.e. the "Faraglione" (= stack) of Levanzo (hereinafter named "FLE") and 3 satellite islets of Favignana, i.e. Prèveto ("PRE"), Galeotta ("GAL"), and a little islet without any official name situated within Cala Rotonda and therefore indicated as "ROT" (Figs. 1-5).

The present study enters the strand of recent investigations on the botanical features of circum-Sicilian satellite islets (Siracusa, 1996; Pasta, 1997a, 2001, 2002; Scuderi et al., 2007; Pasta & Scuderi, 2008; Lo Cascio & Pasta, 2008b, 2012; Sciberras & Sciberras, 2012) and updates the available information on the vascular flora of Egadi Archipelago (Di

Martino & Trapani, 1967; Gianguzzi et al., 2006; Romano et al., 2006). Some rough information on the vegetation and the fauna of the islets is given, too.

Basic information on the study area

All the studied islets are characterized by Jurassic or Cretaceous calcareous rocks, although some spots of outcropping marls and radiolarites have been recorded on PRE (Abate et al., 1997). The available information on the rainfall and temperature regimes of the nearest climate recording station, i.e. Trapani (Zampino et al., 1997) suggests that the islets are all subject to the same bioclimatic type, which is upper thermo-mediterranean dry according to Rivas-Martínez (2008) classification.

During Last Glacial Maximum (i.e. c. 18-12 Kyrs BP), the sea level was some 80-120 m lower than today (Lambeck et al., 2010), so that all the considered islets were part of the main islands, and they must have been connected with them at least till 8 Kyrs BP (Agnesi et al., 1993; Antonioli et al., 2002).

Malatesta (1957) noticed plenty of lithic artifacts on PRE. No other information seems to be available on the past land use and human presence on the islets. Besides, a lot of potsherds have been observed on the flat inland of PRE, which also hosts a little and rough cubic structure, probably built up some decades ago by shepherds, who used to transfer on PRE their animals during summer, in order to have a shady and fresh place where to eat and rest. Moreover, along the eastern border of FLE a sort of path was noticed, perhaps produced by intense trampling due to the presence of herbivores left on the islet during summer season. The main geographical characteristics of the islets are summarized in Table 1.

MATERIAL AND METHODS

A specimen of *Parapholis pycnantha* (Hack.) C.E. Hubb. (Poaceae), quoted by Cuccuini (2002), testifies that Giovanni Gussone, the indefatigable botanist who explored every hidden spot of Sicily and wrote down the most detailed checklist of Sicilian vascular flora ever published, visited FLE during his botanical expedition to Egadi islands during May 1829 (Pasquale, 1876; Trotter, 1948). The only recent data on FLE flora and vegetation were collected by S. Pasta during a short visit some twenty years ago (April 1995; hereinafter indicated as SP0). More recently the investigation on the vascular flora of the four islets was carried out through five visits between 2004 and 2010. More in detail, three of them were carried out by S. Pasta and L. Scuderi (PRE: SP-LS1, 21/09/2004; PRE and GAL: SP-LS2, 14/08/2005; FLE: SP-LS3, 27/09/2005), while A. and J. Sciberras first visited PRE and GAL (A-JS1, 10/10/2010) and then ROT (A-JS2, 17/10/2010).

The classification of the observed plants was carried out mainly using Pignatti (1982) and Tutin et al. (1964-1980, 1993), while their nomenclature is mainly based on Euro+Med (2006). Moreover, the families are circumscribed according to the most recent proposals of Angiosperm Phylogeny Group (APG, 2009; Reveal & Chase, 2011), while families, genera and infrageneric taxa are listed in alphabetical order.

The check-list also provides basic information on life forms (Raunkiær, 1934) and chorotypes (according to Pasta, 1997b) or xenophyte status (Richardson et al., 2000). In order to perform a better interpretation of the floristic similarity among the islets, the niche width of each taxon was taken

Code	Per (m)	Surface (ha)	Dist (m)	ME (m)	UTM coordinates
PREV	1,240	4.319	224	8	E 262835.73 - N 4199765.67
GAL	453	0.706	420	2	E 262512.94 - N 4199493.17
ROT	305	0.423	1	4	E 260929.07 - N 4200840.57
FLE	489	0.959	46	20	E 265383.93 - N 4207687.67

Table 1. Main geographic features of the investigates islets. Per: perimeter; Dist: minimum distance from the main island; ME: maximum elevation above sea level.

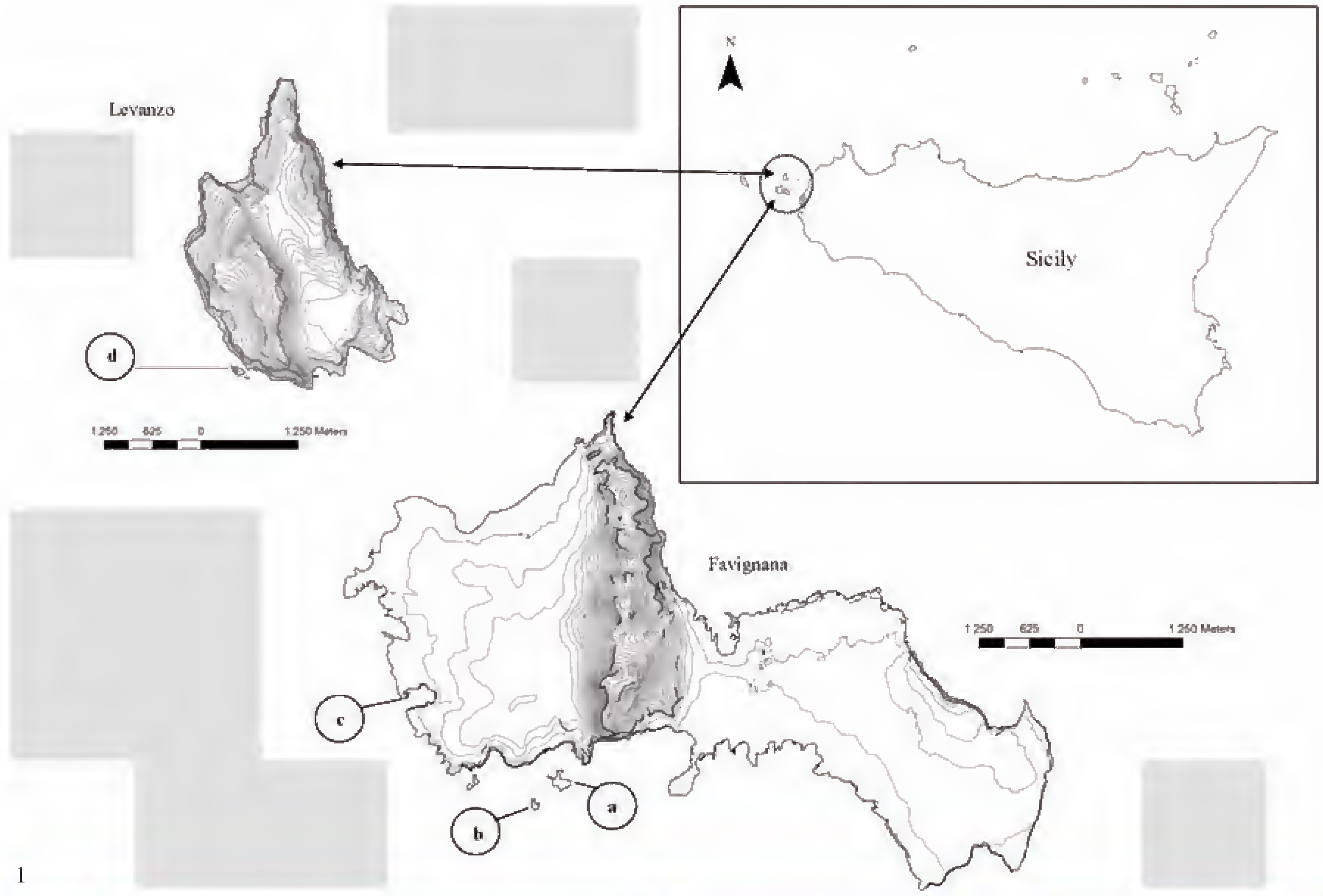


Figure 1. Location of the investigated islets. a: Prèveto (PRE); b: Galeotta (GAL); c: islet of Cala Rotonda (ROT); d: Faraglione di Levanzo (FLE). Figure 2. Prèveto and Galeotta from the southern coast of Favignana (photo L. Scuderi). Figure 3. The Islet of Galeotta from Prèveto (photo A. Sciberras). Figure 4. Cala Rotonda islet from the coast of Favignana (photo A. Sciberras). Figure 5. Faraglione di Levanzo from the south-eastern coast of Levanzo (photo L. Scuderi).

into account through Ellenberger's bioindication values (data from Pignatti, 2005, modified), i.e. L (light, whose range of variation is from 1 to 9), T (temperature, 1-9), C (continentality, 1-9), U (moisture, 1-12), R (soil pH, 1-9), N (soil fertility, 1-9) and S (soil salinity, 1-3). Basic information used for data elaboration is contained in Table 2. In this Table 2 the Column "LF" contains information on Raunkiaer's life forms. Columns 2-8 refer to Ellenberger's bioindication values as follows: L (light), T (temperature,), C (continentality), U (moisture), R (soil pH), N (soil fertility) and S (soil salinity). For further information on the range of these values see the text in "Material and Methods" paragraph. Column "Choro" illustrates the chorotype of each plant. In the last four columns the presence ("1") or absence ("0") of each detected vascular plant is reported.

Moreover, the main literature concerning coastal Sicilian vegetation (Bartolo et al., 1982; Brullo et al., 2001; Minissale et al., 2010) has been consulted in order to facilitate the interpretation of local plant communities.

Data on fauna were collected as a broad brush baseline survey of all the specimens (including remains, traces and faecal pellets) encountered. Identifications of most invertebrate species were carried out according to Fontana et al. (2002).

RESULTS

The vascular flora

AIZOACEAE

Malephora crocea (Jacq.) Schwantes - Ch succ - Naturalized: FLE (LS-SP3)

Mesembryanthemum crystallinum L. - T rept - Subcosmopolitan: PRE (LS-SP2; A-JS1)

Mesembryanthemum nodiflorum L. - T rept - Tethyan-Capensis: PRE (LS-SP2; A-JS1); FLE (SP0; LS-SP3)

AMARANTHACEAE

Arthrocnemum macrostachyum (Moric.) K. Koch - NP succ - Mediterranean-Irano-Turanian: PRE (LS-SP1, LS-SP2; A-JS1); GAL (LS-SP2; A-JS1); ROT (A-JS2); FLE (SP0; LS-SP3)

Beta maritima L - H scap - Mediterranean-Atlantic: PRE (LS-SP2; A-JS1)

Chenopodium murale L. - T scap - Subcosmopolitan: PRE (LS-SP2; A-JS1)

Chenopodium opulifolium Schrad. - T scap - Subcosmopolitan: GAL (A-JS1)

† *Halimione portulacoides* (L.) Aellen - NP - Tethyan-European: GAL (LS-SP2)

Suaeda vera J.F. Gmelin - Ch frut - Tethyan-Atlantic: PRE (LS-SP1, LS-SP2; A-JS1); GAL (LS-SP2; A-JS1)

AMARYLLIDACEAE

Allium commutatum Guss. - G bulb - Mediterranean: PRE (LS-SP2; A-JS1); GAL (LS-SP2; A-JS); FLE (SP0; LS-SP3)

ANACARDIACEAE

Pistacia lentiscus L. - P caesp - Mediterranean: FLE (SP0; LS-SP3)

APIACEAE

Crithmum maritimum L. - Ch suffr - Mediterranean-Atlantic: GAL (LS-SP2; AJ&JS1); ROT (AJ&JS2); FLE (SP0; LS-SP3)

Daucus bocconei Guss. - H bienn - CW Mediterranean: FLE (SP0; LS-SP3)

Ferula communis L. - H scap - Mediterranean-Macaronesian: PRE (LS-SP2)

Thapsia garganica L. subsp. *garganica* - H scap - CW Mediterranean: PRE (LS-SP2; A-JS1)

ARACEAE

Arisarum vulgare Targ.-Tozz. - G rhiz - Mediterranean: PRE (LS-SP2; A-JS1); FLE (LS-SP3)

ARECACEAE

Chamaerops humilis L. - NP - CW Mediterranean: FLE (SP0; LS-SP3)

ASPARAGACEAE

Asparagus acutifolius L. - G rhiz - Mediterranean: PRE (LS-SP2); FLE (LS-SP3)

Asparagus aphyllus L. - Ch frut - S Mediterranean: ROT (A-JS2)

Prospero autumnale (L.) Speta (= *Scilla autumnalis* L.) - G bulb - Tethyan-European: ROT (A-JS2)

ASTERACEAE

Anthemis secundiramea Biv. - T scap - CW Mediterranean: FLE (SP0; LS-SP3)

Bellis annua L. - T scap - Tethyan: PRE (A-JS1)

Calendula arvensis L. - T scap - Tethyan-European: PRE (A-JS1)

Carduus pycnocephalus L. - H bienn - Tethyan-European: PRE (LS-SP2; A-JS1)

Galactites tomentosa Moench - H bienn - Mediterranean: PRE (LS-SP2; A-JS1)

Helichrysum panormitanum Tineo [= *H. rupestre* (Raf.) DC.] - Ch frut - NW Sicilian endemic: FLE (LS-SP3)

Jacobaea maritima (L.) Pelser et Meijden subsp. *bicolor* (Willd.) B. Nord. et Greuter [= *Senecio bicolor* (Willd.) Tod.] - Ch frut - CW Medit: FLE (LS-SP3)

Limbarda crithmoides (L.) Dumort. (= *Inula crithmoides* L.) - Ch suffr - CS - Mediterranean-Atlantic: ROT (A-JS2); FLE (SP0; LS-SP3)

Senecio leucanthemifolius Poir. s.l. - T scap - CW Mediterranean: PRE (LS-SP2; A-JS1); GAL (LS-SP2; A-JS1); ROT (A-JS2)

Sonchus oleraceus L. - T scap - Boreal-Tethyan: PRE (LS-SP2; A-JS1); GAL (A-JS1); FLE (LS-SP3)

Sonchus tenerrimus L. - T scap - Tethyan-Paleotropical: PRE (A-JS1)

Xanthium strumarium L. subsp. *italicum* (Moretti) D. Löve - T scap - Subcosmopolitan: ROT (A-JS2)

BORAGINACEAE

Echium plantagineum L. - H bienn - Tethyan-European: PRE (LS-SP2; A-JS1); FLE (LS-SP3)

Heliotropium europaeum L. - T scap - Tethyan-European: PRE (LS-SP1, LS-SP2; A-JS1)

BRASSICACEAE

Diplotaxis erucoides (L.) DC. - T scap - Mediterranean: PRE (A-JS1)

Iberis semperflorens L. - Ch suffr - Central Mediterranean: FLE (LS-SP3)

Lobularia maritima (L.) Desv. - H scap - Medit: FLE (SP0; LS-SP3)

CAPPARACEAE

Capparis spinosa L. subsp. *rupestris* (Sibth. et Sm.) Nyman - NP - Mediterranean - PRE (LS-SP1, LS-SP2, A-JS1); GAL (LS-SP2; A-JS1); ROT (A-JS2); FLE (SP0; LS-SP3)

CARYOPHYLLACEAE

Dianthus rupicola Biv. subsp. *rupicola* - Ch frut - Apulian-Sicilian endemic: FLE (LS-SP3)

Polycarpon alsinifolium (Biv.) DC. - T scap - S Mediterranean-Atlantic: PRE (LS-SP2)

Silene sedoides Poir. subsp. *sedoides* - T scap - Mediterranean: PRE (LS-SP2); GAL (LS-SP2); FLE (LS-SP3)

CRASSULACEAE

Sedum litoreum Guss. - T succ - Mediterranean: PRE (LS-SP2)

CUCURBITACEAE

Ecballium elaterium (L.) A. Rich. - H scand - Tethyan-Pontic: PRE (LS-SP1, LS-SP2; A-JS1)

EUPHORBIACEAE

Euphorbia segetalis L. (incl. *E. pinea* L.) - Ch suffr - CW Mediterranean: PRE (A-JS2); ROT (A-JS2)

Mercurialis annua L. - T scap - R - Tethyan-European: PRE (LS-SP1, LS-SP2; A-JS1)

FABACEAE

Lotus cytisoides L. - Ch suffr - Mediterranean: ROT (A-JS2)

FRANKENIACEAE

Frankenia hirsuta L. - Ch suffr - Mediterranean-Pontic: FLE (LS-SP3)

Frankenia pulverulenta L. - T scap - Tethyan-Pontic: PRE (LS-SP2)

GENTIANACEAE

Centaurium tenuiflorum (Hoffmgg. et Link) Fritsch - T scap - Mediterranean: PRE (LS-SP2)

GERANIACEAE

Erodium malacoides (L.) L'Hérit. - T scap - Tethyan: PRE (A-JS1)

Erodium moschatum (L.) L'Hérit. - T scap - Mediterranean-European: PRE (A-JS1)

LAMIACEAE

Sideritis romana L. - T scap - Mediterranean: PRE (LS-SP2); FLE (LS-SP3)

MALVACEAE

Malva arborea (L.) Webb. et Berthel. [= *Lavatera arborea* L.) - H bienn - Mediterranean-Atlantic: PRE (LS-SP1, LS-SP2; A-JS1)

Malva multiflora (Cav.) Soldano, Banfi et Galasso [= *Lavatera cretica* L.] - T scap - Mediterranean: PRE (A-JS1)

PLUMBAGINACEAE

Limonium aegusae Brullo - Ch suffr - endemic of Favignana: ROT (A-JS2)

Limonium bocconei (Lojac.) Litard. - Ch suffr - NW Sicilian endemic: PRE (LS-SP2)

Limonium lojaconoi Brullo - Ch suffr - NW Sicilian endemic: FLE (LS-SP3)

Limonium ponzoi (Fiori et Bég.) Brullo - Ch suffr - W Sicilian endemic: FLE (LS-SP3)

POACEAE

Avena cfr. *barbata* Link - T scap - Tethyan-Pontic: PRE (A-JS1)

Brachypodium retusum (Pers.) P. Beauv. - H caesp - Mediterranean: FLE (LS-SP3)

Catapodium pauciflorum (Merino) Brullo, Giusso, Minissale et Spampinato - T scap - CW Mediterranean: FLE (LS-SP3)

Catapodium rigidum C.E. Hubb. subsp. *rigidum* - T scap - Tethyan-European: FLE (LS-SP3)

Dactylis glomerata Roth. L. subsp. *hispanica* (Roth) Nyman - H caesp - Mediterranean: FLE (SP0; LS-SP3)

Hordeum leporinum Link - T scap - Mediterranean-European: PRE (LS-SP2)

Lagurus ovatus L. s.l. - T scap - Mediterranean-Atlantic: PRE (AS & JS 1)

Parapholis incurva (L.) C.E. Hubb. - T scap - Tethyan-Eurosibirian: PRE (LS-SP2); GAL (LS-SP2); FLE (SP0; LS-SP3)

Parapholis pycnantha (Hack.) C.E. Hubb. - T scap - CW Mediterranean: FLE (LS-SP3)

† *Sporobolus pungens* (Schreb.) Kunth - G rhiz - Holarctic-Paleotropical: GAL (LS-SP2)

RANUNCULACEAE

Ranunculus bullatus L. - G bulb - R - Mediterranean: PRE (LS-SP2)

RUBIACEAE

Valantia muralis L. - T scap - R - Mediterranean: PRE (LS-SP2); FLE (LS-SP3)

SOLANACEAE

Hyoscyamus albus L. - T scap - Mediterranean-Macaronesian: GAL (LS-SP2; A-JS1)

Mandragora autumnalis Bertol. - H ros - Mediterranean: PRE (LS-SP1, LS-SP2; A & ES1)

Solanum lycopersicum L. (= *Lycopersicon esculentum* Mill.) - T scap - Casual alien: PRE (A & ES1)

URTICACEAE

Parietaria lusitanica L. - H scap - Tethyan-European: PRE (LS-SP2)

Urtica membranacea Poir. - T scap - Mediterranean-Macaronesian: PRE (A-JS1)

Two sea-grasses, *Cymodocea nodosa* (Ucria) Asch. and *Posidonia oceanica* (L.) Delile, quite common along the coasts of Egadi islands (Giaccone et al., 1985) and present near all the considered islets, do not figure within the list. The symbol † underlines that *Halimione portulacoides* and *Sporobolus pungens*, were no more observed in GAL. Considering their perennial life-cycle, the very little size of both their local population and the islet, they must be considered as locally extinct and therefore excluded from further data elaboration.

Main structural and floristic patterns of local plant communities

The distribution and the floristic assemblage of the observed plant communities firstly depends on the size and the topography (e.g. flat areas, rocky cliffs, even or steep shores, etc.) of the islets.

The natural landscape of PRE is also shaped by the disturbance induced by a huge breeding colony of yellow-legged seagulls (at least 60 pairs), which causes important changes on both the structure and chemistry of the soil due to trampling and to organic matter input, respectively (see Caldarella et al., 2010, and references therein). In fact, the northern half of its inland area (Fig. 6), where most part of the nesting sites are concentrated, holds a ruderal community referred to *Stellarietea mediae* R. Tx. Lohmeyer et Preising ex von Rochow 1951, rather rich in annual pioneer plants which are quite common in disturbed places, arable lands and in fallow communities; among them, *Malva arborea* and *Carduus pycnocephalus* are the most common and dominant species.

LF	L	T	C	U	R	N	S	Choro	Scientific name
G	7	7	5	3	6	5	2	Med	*Allium commutatum* Guss.
T	11	11	5	1	3	1	3	CW Med	*Anthemis secundiramea* Biv.
G	6	8	4	4	4	4	0	Med	*Arisarum vulgare* Targ.-Tozz.
NP	11	9	5	8	9	7	3	Med-Ir-Tur	*Arthrocnemum macrostachyum* (Moric.) K. Koch
G	6	9	4	2	5	5	0	Med	*Asparagus acutifolius* L.
Ch	8	8	5	3	7	2	0	S Med	*Asparagus aphyllus* L.
T	8	8	5	3	7	2	0	Tet-Pont	*Avena* cfr. *barbata* Link
T	6	9	4	7	2	2	0	Tet	*Bellis annua* L.
H	11	7	4	6	6	5	2	Med-Atl	*Beta maritima* L.
H	11	10	3	2	5	2	0	Med	*Brachypodium retusum* (Pers.) P. Beauv.
T	7	8	5	3	8	5	0	Tet-Eur	*Calendula arvensis* L.
NP	9	10	5	2	5	1	1	Med	*Capparis spinosa* L. subsp. *rupestris* (Sibth. & Sm.) Nyman
H	7	8	4	3	X	3	0	Tet-Eur	*Carduus pycnocephalus* L.
T	11	10	3	1	X	1	2	CW Medit	*Catapodium pauciflorum* (Merino) Brullo, Giusso, Minissale et Spampinato
T	8	8	5	2	5	4	0	Tet-Eur	*Catapodium rigidum* C.E. Hubb. subsp. *rigidum*
T	9	8	5	7	7	2	0	Med	*Centaurium tenuiflorum* (Hoffmgg. et Link) Fritsch
NP	11	10	3	1	4	1	0	CW Med	*Chamaerops humilis* L.
T	8	7	5	4	X	9	0	Subcosmop	*Chenopodium murale* L.
T	8	7	5	3	X	6	0	Subcosmop	*Chenopodium opulifolium* Schrad.
Ch	11	8	2	1	X	1	3	Med-Atl	*Crithmum maritimum* L.
H	11	8	4	2	5	2	0	Med	*Dactylis glomerata* L. subsp. *hispanica* (Roth) Nyman
H	8	6	5	4	5	4	3	CW Med	*Daucus bocconei* Guss.
Ch	11	10	3	2	7	1	1	End Apul-Sic	*Dianthus rupicola* Biv. subsp. *rupicola*
T	8	8	4	3	5	5	0	Med	*Diplotaxis erucoides* (L.) DC.
H	7	8	5	3	5	3	1	Tet-Pont	*Ecballium elaterium* (L.) A. Rich.

Table 2. Basic information used for data elaboration. LF = life forms according to Raunkiær (1934); for the meaning of the abbreviations of the following 7 columns, please see Ellenberger bioindicator values in “Material and Methods” paragraph; Choro = chorotype (continued).

LF	L	T	C	U	R	N	S	Choro	Scientific name
H	11	8	5	3	5	5	0	Tet-Eur	*Echium plantagineum* L.
T	11	9	4	2	5	2	0	Tet	*Erodium malacoides* (L.) L'Hérit.
T	11	9	5	2	5	2	0	Med-Eur	*Erodium moschatum* (L.) L'Hérit.
Ch	11	10	4	2	0	2	0	CW Med	*Euphorbia segetalis* L.
H	9	8	5	3	5	2	0	Med-Mac	*Ferula communis* L.
Ch	11	10	4	1	7	1	3	Med-Pont	*Frankenia hirsuta* L.
T	11	9	4	1	7	1	3	Tet-Pont	*Frankenia pulverulenta* L.
H	8	8	4	3	X	7	0	Med	*Galactites tomentosa* Moench
Ch	11	9	3	2	7	1	0	End NW Sic	*Helichrysum panormitanum* Tineo
T	11	8	5	3	7	2	1	Tet-Eur	*Heliotropium europaeum* L.
T	9	9	5	3	5	3	0	Med-Eur	*Hordeum leporinum* Link
T	8	8	5	2	X	9	1	Med-Mac	*Hyoscyamus albus* L.
Ch	6	8	3	3	6	2	0	C Med	*Iberis semperflorens* L.
Ch	11	10	3	1	X	1	3	CW Med	*Jacobaea maritima* (L.) Pelser et Meijden subsp. *bicolor* (Willd.) B. Nord. et Greuter
T	8	9	5	3	X	2	1	Med-Atl	*Lagurus ovatus* L. *s.l.*
Ch	11	8	4	7	9	5	3	Med-Atl	*Limbarda crithmoides* (L.) Dumort.
Ch	11	10	3	1	9	1	3	End Favign	*Limonium aegusae* Brullo
Ch	11	10	3	1	9	1	3	End NW Sic	*Limonium bocconei* (Lojac.) Litard.
Ch	11	10	3	1	9	2	3	End NW Sic	*Limonium lojaconoi* Brullo
Ch	11	10	3	1	9	1	3	End NW Sic	*Limonium ponzoi* (Fiori et Bég.) Brullo
H	8	9	4	2	X	1	0	Med	*Lobularia maritima* (L.) Desv.
Ch	11	10	3	1	X	1	2	Med	*Lotus cytisoides* L.
Ch	11	12	5	1	X	1	2	Naturalized	*Malephora crocea* (Jacq.) Schwantes
H	8	9	4	2	5	4	3	Med-Atl	*Malva arborea* (L.) Webb. & Berthel.

Table 2 (continued). Basic information used for data elaboration. LF = life forms according to Raunkiær (1934); for the meaning of the abbreviations of the following 7 columns, please see Ellenberger bioindicator values in "Material and Methods" paragraph; Choro = chorotype (continued).

LF	L	T	C	U	R	N	S	Choro	Scientific name
T	8	9	4	2	5	4	3	Med	*Malva multiflora* (Cav.) Soldano, Banfi et Galasso
H	7	9	4	2	7	3	0	Med	*Mandragora autumnalis* Bertol.
T	7	7	5	4	7	8	1	Tet-Eur	*Mercurialis annua* L.
T	11	11	5	1	X	1	2	Subcosmop	*Mesembryanthemum crystallinum* L.
T	11	12	5	1	X	1	3	Tet-Cap	*Mesembryanthemum nodiflorum* L.
T	11	7	4	5	7	2	3	Tet-Eurosib	*Parapholis incurva* (L.) C.E. Hubb.
T	11	7	4	5	7	2	3	CW Medit	*Parapholis pycnantha* (Hack.) C.E. Hubb.
H	7	10	4	3	4	6	0	Tet-Eur	*Parietaria lusitanica* L.
P	11	10	5	2	X	2	0	Med	*Pistacia lentiscus* L.
T	11	11	5	2	7	3	0	S Medit-Atl	*Polycarpon alsinifolium* (Biv.) DC.
G	8	8	4	2	6	3	0	Tet-Eur	*Prospero autumnale* (L.) Speta
G	7	8	4	2	7	2	0	Med	*Ranunculus bullatus* L.
T	11	10	5	2	3	1	2	Med	*Sedum litoreum* Guss.
T	11	9	4	2	9	3	2	CW Med	*Senecio leucanthemifolius* Poir. *s.l.*
T	11	9	4	2	6	1	0	Med	*Sideritis romana* L.
T	11	10	3	2	2	1	2	Med	*Silene sedoides* Poir. subsp. *sedoides*
T	7	7	X	5	5	7	1	Casual	*Solanum lycopersicum* L.
T	7	5	X	4	8	8	0	Bor-Tet	*Sonchus oleraceus* L.
T	7	8	4	2	5	4	1	Tet-Paleotrop	*Sonchus tenerrimus* L.
Ch	11	10	5	8	9	7	3	Tet-Atl	*Suaeda vera* J.F. Gmelin
H	11	8	5	3	5	3	0	CW Med	*Thapsia garganica* L. subsp. *garganica*
T	7	8	5	3	6	3	0	Med-Mac	*Urtica membranacea* Poir.
T	11	9	4	2	3	1	0	Med	*Valantia muralis* L.
T	8	8	5	5	X	1	0	Subcosmop	*Xanthium strumarium* L. subsp. *italicum* (Moretti) D. Löve

Table 2 (continued). Basic information used for data elaboration. LF = life forms according to Raunkiær (1934); for the meaning of the abbreviations of the following 7 columns, please see Ellenberger bioindicator values in “Material and Methods” paragraph; Choro = chorotype.

The second half of PRE, more exposed to southern winds and, thus, to salt-spray, is less disturbed by seagulls and it is covered by a species-poor chenopod halo-xero-nitrophilous scrubland dominated by *Suaeda vera* (SE) or by *Arthrocnemum macrostachyum* (SW and S) and referred to the class *Sarcocornietea fruticosae* Br.-Bl. et R. Tx. ex A. et O. de Bolòs 1950 em. O. de Bolòs 1967.

ROT is characterized by a low halophilous shrubland ascribed to *Crithmo-Limonietea* Br.-Bl. in Br.-Bl., Roussine et Nègre 1952 and dominated by *Limbarda crithmoides* and *Limonium aegusae* (Fig. 7).

Due to its extremely low elevation and its even topography, no plant communities could be detected on GAL, except from a little *Arthrocnemum macrostachyum* halophilous scrub. It worths to be emphasized the local frequency of *Hyoscyamus albus*, a plant which is normally associated with sheltered/shaded nutrient-rich ruderal communities, a pattern also observed at Maraone (S. Pasta pers. obs.).

Probably due to its shape and elevation FLE shows the highest richness in terms of number of plant communities. In fact, its bare and rocky coasts host a mosaic-like vegetation dominated by halophilous species-poor chenopod scrubland referred to *Sarcocornietea fruticosae* intermingled with little spots of therophytic vegetation ascribed to *Saginetea maritimae* Westhoff, Van Leeuwen et Adriani 1962, the base of the rocky and steep inland is colonized by several species of the class *Crithmo-Limonietea*, and the cliffs host some perennial grassland species, truly rupicolous species such as *Dianthus rupicola* subsp. *rupicola* and even a little nucleus of low, scattered and extremely simplified maquis with *Chamaerops humilis*, *Pistacia lentiscus* and *Asparagus acutifolius*.

Notes on the invertebrate fauna

As concerns PRE, a remarkable number of animals was collected and/or recorded during A & JS 1 visit on the islet. Except from *Cantareus apertus* (Born, 1778), all the other (8 species) collected species of terrestrial Mollusca still await identification. So goes for three species of *Lepisma* Linnaeus, 1758 and for four species of Hymenoptera. Two specimens of one species of Formicidae were also collected. Moreover, several individuals of Orthoptera, like *Calliptamus barbarus* (Costa, 1836), *Aiolopus strepens* (Latreille, 1804), *Anacridium aegyptium* (Linnaeus, 1758), *Eyprepocnemis plorans* (Charpentier, 1825) and *Acrida* sp. (Acrididae) were observed. Among the few collected Coleoptera it has been possible to identify the narrow endemic *Otiorhynchus* (*Arammichnus*) *aegatensis* (Solari et Solari, 1913). More detailed information on the animals observed/collected at PRE is provided in Table 3.

Phylum	Order	Family	Species	Nr ind.	Status
Mollusca	Gastropoda	Helicidae	*Cantareus apertus*	53	A
Arthropoda	Orthoptera	Acrididae	*Calliptamus barbarus*	c. 15	A
Arthropoda	Orthoptera	Acrididae	*Aiolopus strepens*	3	A
Arthropoda	Orthoptera	Acrididae	*Anacridum aegyptium*	7	B
Arthropoda	Orthoptera	Acrididae	*Eyprepocnemis plorans*	73	A
Arthropoda	Coleoptera	Curculionidae	*Otiorhynchus* (*Arammichnus*) *aegatensis*	11	A

Table 3. Prospect, number of individuals and status of the identified terrestrial invertebrates observed and/or collected by A & JS during their visit to PRE. Abbreviations concerning the "status" column: A = living and B = living and/or migratory.

Notes on the vertebrate fauna

As concerns reptiles, *Tarentola mauritanica* (Linnaeus, 1758) was observed close to the abandoned building. Interestingly, *Podarcis siculus* (Rafinesque, 1810) was the only lizard found at PRE (Fig. 8), while at Favignana it co-occurs with *Podarcis waglerianus* (Gistel, 1868) (Corti et al., 1998, 2006). It was also observed on ROT (Fig. 9). On both islets it performs very high densities like elsewhere in Mediterranean microinsular biota (Lo Cascio & Pasta, 2006, 2008a; Sciberras, 2007; Sciberras & Sciberras, 2014).

Oryctolagus cuniculus (Linnaeus, 1758) and *Rattus norvegicus* (Berkenhout, 1769) were collected at PRE and both were observed on the islet. Local rabbit population appears to be very massive. Some vertebrae (8) and a lower jaw bone of *Mustela nivalis* (Linnaeus, 1766) were collected from site but no living individuals were encountered. Among the observed bird species (data not shown), only the permanent presence of *Larus michahellis* (Naumann, 1840) is very much evident.

No terrestrial fauna was encountered on GAL. Several *Larus michahellis* were observed on ROT and GAL. Due to the total lack of traces of nesting material, both islets probably are only perching/resting sites. As concerns FLE, it represents the nesting site of few pairs of yellow-legged seagulls and hosts a population of *Podarcis siculus*. The presence of numerous mounds of olive seeds suggests the occasional visit of Turdidae; most of these seeds are bitten by a rodent, probably *Rattus rattus* (Linnaeus, 1758).

Figure 6. The flat top of Prèveto (photo A. Sciberras). Figure 7. The natural landscape of Cala Rotonda islet (photo A. Sciberras). Figure 8. *Podarcis siculus* at Prèveto islet (photo A. Sciberras). Figure 9. *Podarcis siculus* at Cala Rotonda islet (photo A. Sciberras).

DISCUSSION

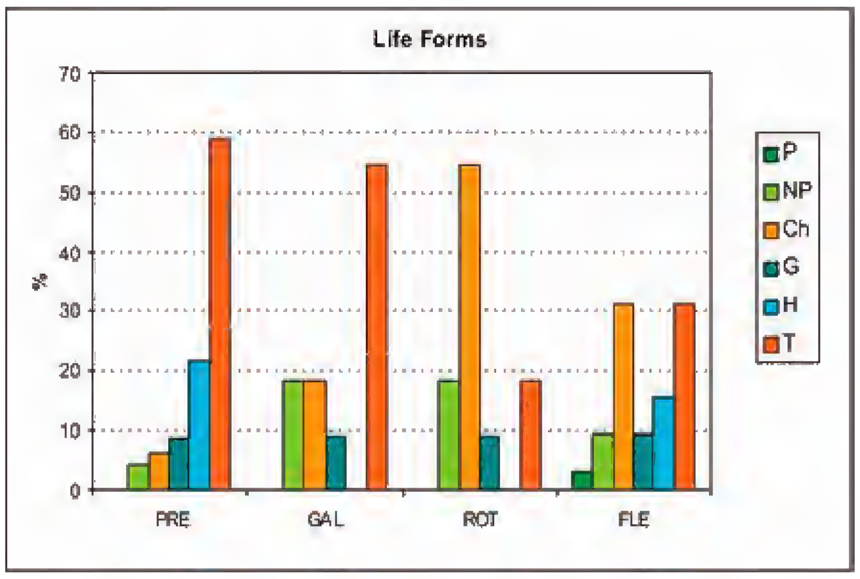
Phytogeographical insight on the local vascular flora

The 73 terrestrial vascular plants recorded on the four considered islets belong to 28 different families (the most represented being Asteraceae, Poaceae and Amaranthaceae with 12, 11 and 6 infrageneric taxa, respectively) and 62 genera. If we consider absolute values, the richest islet is PRE with 46 taxa, followed by FLE (32), while both GAL and ROT host only 11 species. A simplified analysis of species/area relationship seems to separate the most isolated islets from those that are near to the main islands. In fact, the value of the rate nr taxa/m^2 is 0.011 and 0.015 for PRE and GAL, respectively, while it is 0.026 for ROT and 0.033 for FLE.

Although the striking differences concerning both the life-form spectrum (e.g. stark prevalence of therophytes only on PRE and GAL, high variability of the percentage of chamaephytes, total absence of hemicryptophytes in GAL and ROT: Fig. 10) and the chorological spectrum (e.g. absolute dominance of Mediterranean taxa only on FLE: Fig. 11) are still unexplained, this is not such a rare pattern on the very little islets, which often represent 'unbalanced biota'.

As for Ellenberg bioindicators values (Fig. 12), only R show some significant - and yet unexplained - variation between PRE e GAL (very high) and FLE (very low).

Although no real islet specialists have been detected, it should be underlined that the only two taxa whose presence has been recorded on all the four considered islets, i.e. *Arthrocnemum macrostachyum* and *Capparis spinosa* subsp. *rupestris*, are very common in all the circum-Sicilian islets and stacks (Pasta, 1997a).



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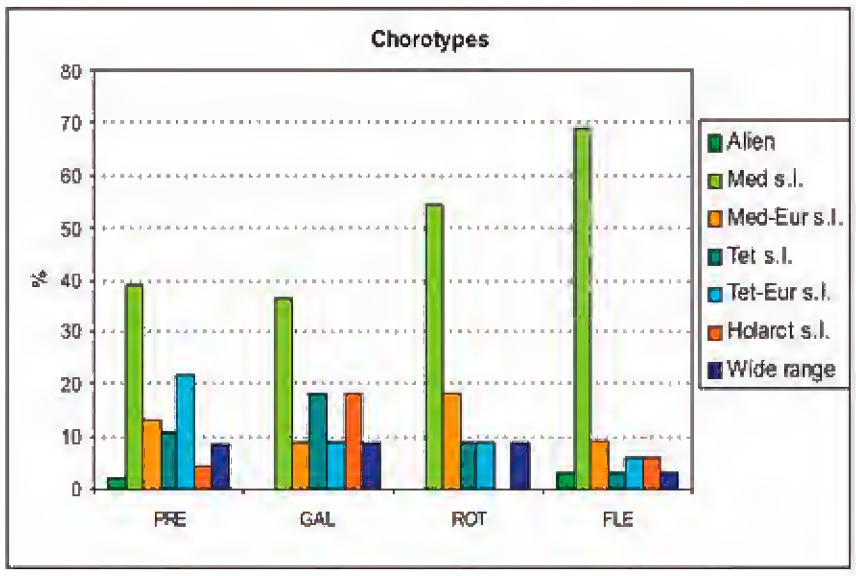

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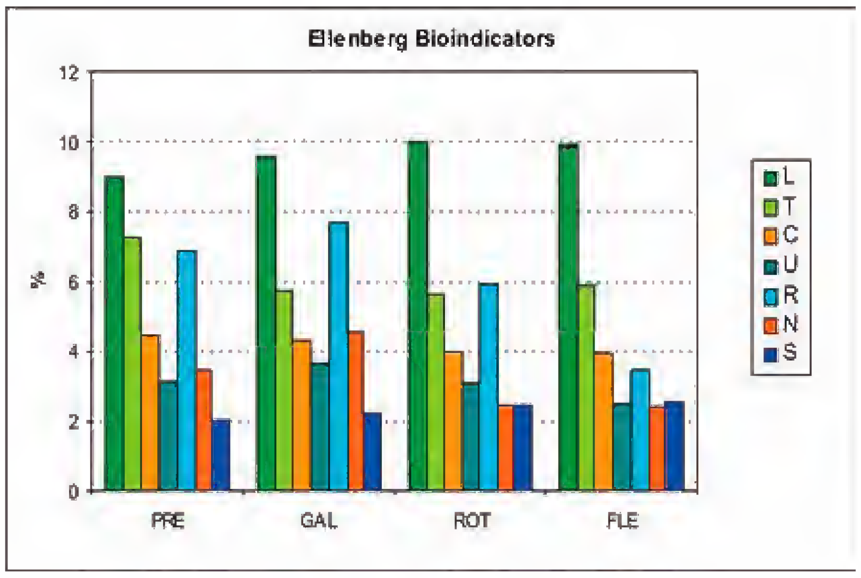

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Figure 10. Life-form spectrum of the vascular flora of each islet. Figure 11. Chorological spectrum of the vascular flora of each islet. Figure 12. average values of Ellenberg indicators concern-ing the vascular flora of each islet.

Faunistic notes

The detected remains of *Mustela nivalis* on PRE represent the first record of the species for the whole Egadi Archipelago (Sarà, 1998; Siracusa & Lo Duca, 2008). Its regular presence on the islet seems quite improbable, while it might have reached PRE as a carcass picked up by a seagull or as a prey of the barn-owl, *Tyto alba* (Scopoli, 1769), or the buzzard, *Buteo buteo* (Linnaeus, 1758), two birds which occasionally feed on it according to Sarà & Zanca (1988) and Siracusa & Lo Duca (2008), respectively. As the western coast of Sicily seems to be too far away from PRE, future investigations on its occurrence should start from Favignana.

Considering that *Podarcis siculus* shows a high morphological plasticity and that all the micro-insular races described in the past are now treated as mere synonyms of the species, an accurate field data collection focused on many different meristic and morphological parameters should be carried out in order to assess the pattern and the range of variability of PRE and ROT lizard populations.

CONCLUSIONS

Small areas, few or no available niches: effects on microinsular assemblages

If compared with other islets with a similar size, like Strombolicchio on Aeolian Islands (Lo Cascio & Pasta, 2008a) or Lampione on Pelagian Archipelago (Lo Cascio & Pasta, 2012), the studied islets do not show a remarkable botanical value. Nonetheless, they give hospitality to nine species of biogeographic and/or conservation interest, i.e. *Dianthus rupicola* subsp. *rupicola*, *Iberis semperflorens*, *Limonium aegusae*, *Limonium bocconei*, *Limonium lojaconoi* (Fig. 13), *Limonium ponzoi*, *Helichrysum panormitanum*, *Polycarpon alsinifolium* and *Silene sedoides* subsp. *sedoides*, and to several plants which became extinct or are extremely rare on Egadi islands: for example, at FLE thrive 4 out of less than 10 plants of *Chamaerops humilis* present in the whole Egadian archipelago, while PRE hosts perhaps the last individual of *Ranunculus bullatus*, apparently extinct at Favignana (S. Pasta, pers. obs.). The same "refugium" role is played by Strombolicchio, which hosts the only known Aeolian (and Sicilian) populations of *Ephedra podostylax* Boiss. and *Eokochia saxicola* (Guss.) Freitag et G. Kadereit (Lo Cascio & Pasta, 2008b).

On the other hand, only two aliens, probably recently introduced by seagulls, i.e. *Solanum lycopersicum* (PRE) and *Malephora crocea* (FLE), were noticed. The first one behaves as a casual on many little islets (Lo Cascio & Pasta, 2008b; Caldarella et al., 2010), while the second is becoming a more and more frequent invasive within the halo-lithophilous communities of circum-Sicilian islands (Romano et al., 2006).

Figure 13. *Limonium lojaconoi*: Prèveto (photo L. Scuderi)

Goodbye or see you soon?

Although they have visited PRE and GAL nearly in the same period, the check-lists written down by the two different couples of co-authors show rather striking differences, perhaps because of the different intensity and duration of summer drought period. For example, this could be the case of all the 11 species (*Avena* cfr. *barbata*, *Bellis annua*, *Calendula arvensis*, *Chenopodium opulifolium*, *Diplotaxis erucoides*, *Erodium malacoides* and *E. moschatum*, *Lagurus ovatus*, *Solanum lycopersicum*, *Sonchus tenerrimus* and *Urtica membranacea*) which have been observed at PRE only by A & JS. The presence and commonness of these annual pioneer therophytes linked to disturbed habitat is probably subject to annual fluctuations due to local climatic regime and species patterns (e.g. low numbered and/or extremely localized populations).

The same goes also for 13 of the 15 taxa which have been seen only by LS & SP, i.e. two hemicryptophytes (*Ferula communis* and *Parietaria lusi-

tanica) and 11 therophytes (*Centaurium tenuiflorum*, *Frankenia pulverulenta*, *Hordeum leporinum*, *Parapholis incurva*, *Polycarpon alsinifolium*, *Ranunculus bullatus*, *Sedum litoreum*, *Sideritis romana*, *Silene sedoides* subsp. *sedoides* and *Valantia muralis* which may have been totally undetectable after summer period, while *Limonium bocconei* was probably neglected by A and JS). As concerns *Halimione portulacoides* and *Sporobolus pungens* once recorded at GAL, considering their perennial life-cycle as well as the very little size of the islet, they must be considered as locally extinct.

Rather dramatic changes recently affected many different micro-insular systems of W Mediterranean area (e.g. Bocchieri, 1998; Lo Cascio & Pasta, 2010, 2012; Caldarella et al., 2010). In order to avoid a misinterpretation of Species/Area relationships, an overestimation of species turnover processes and to allow a better understanding of the rate and the driving-forces of such mechanisms, standard, regular and long-lasting data collections are needed (Walter, 2004).

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Spatial distribution of *Calomera littoralis nemoralis* (Olivier, 1790) in a coastal habitat of Southern Italy and its importance for conservation (Coleoptera Carabidae Cicindelinae)

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ABSTRACT The spatial distribution of *Calomera littoralis nemoralis* (Olivier, 1790) (Coleoptera Carabidae Cicindelinae) was studied on the marine sandy beach area of 1 km, near the mouth of a stream in Catanzaro province (Southern Italy, Calabria). During the sampling period (July-August 2011- 2012) we investigated the distribution of adults of *C. littoralis nemoralis* by visual census method and the spatial distribution of larval burrows of *C. littoralis nemoralis* along three transects (A, B, parallel to the coast line; C, embracing the river mouth). All the transects were selected by soil microclimate (a higher or lower humidity) and food availability. Larval burrows distribution was performed using QGIS. The dispersal index (ID) shows regular distribution of adults along transects A and B while in C the individuals are aggregated. Concerning the larval galleries distribution, the QGIS analysis shows a significant difference in their spatial distribution. The sampled data were analyzed using univariate and multivariate statistical methods. This is the first report on spatial distribution of adults and larvae of *C. littoralis nemoralis* in relation to soil humidity and food availability. The adult home range of this species is much larger than the reproductive habitat, that seems limited to wet sandy river bank around the mouth. The importance of such experimental studies for cicindelid conservation is briefly discussed.

KEY WORDS Tiger beetles; *Calomera littoralis*; adults distribution; larval burrows.

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INTRODUCTION

The subfamilia Cicindelinae (Coleoptera Carabidae) classified in the suborder Adephaga includes many species with predatory habits. Both adults and larvae are predators hunting for small arthropods (insects and spiders) (Larochelle, 1974; Pearson, 1988; Pearson & Vogler, 2001) though cannibalistic behavior was descripted in some species (Acorn, 1991; Cassola et al., 1988; Hoback et al., 2001). Adults, usually prey visually and catch them after short and fast running (Gilbert, 1987, 1997; Pearson & Vogler, 2001). Tiger beetles species prefer hunt individually for active and usually fast moving preys (Larochelle, 1974; Wilson, 1978; Gilbert, 1987, 1997; Lovari et al., 1992). Few species have been observed eating on plant material (Hori, 1982; Hill & Knisley, 1992; Jaskuła, 2013) and rarely on

dead vertebrates (Schultz, 1981) or dead arthropods (Świecimski, 1956; Pearson & Vogler, 2001; Riggins & Hoback, 2005). *Calomera littoralis* (Fabricius, 1787) s.l. has wide habitat range compared to other tiger beetles and, in Europe, the species lives in different sandy habitats like sandy beaches, saltmarshes, river and lake banks (Magistretti, 1965; Contarini, 1992; Audisio, 2002; Jaskuła, 2013). *Calomera littoralis nemoralis* (Olivier, 1790) is the comon subspecies distributed along the sandy shores of the Italian peninsula and Sicily (Magistretti, 1965).

Females lay eggs in the sand and the larvae dig a burrow which emerges on the surface of the sand by a steep vertical pit. The larvae feed on insects and they draw back into their dens when the temperature drops. In Italy, in the past, the species was found along the coasts and in Sicily. In the last decade, the human activity has contributed to the disappearance of the species on many Italian coasts (Contarini, 1992). Today in Italy, as well as in other geographical areas, the species is endangered (Zanella et al., 2009). The aim of this paper is to define the spatial distribution of adults and larvae of *C. littoralis nemoralis* in response to human induced disturbance, food availability and habitat suitability, in order to refine basic ecological knowledge for conservation purposes.

Types of spatial distribution of a population

The spatial dispersion of a population is defined as the distribution or disposition of the individuals in the space (Southwood & Henderson 2000). Knowing the type of dispersion of individuals in a population is a highlight in demographic and ecological studies (Tremblay, 2003). The dispersion of the sample data provides important information on the distribution of a population (Pedigo et al., 1994), often closely linked to the ecology and ethology of the species. The pattern of spatial distribution (see Tremblay, 1988) are traditionally classified according to three categories: uniform (uniform, regular, underdispersed) , random (random), and aggregated (clumped, contagious, overdispersed). The statistical measure of aggregation easiest commonly used is the ratio between the variance of the sampling data and the average number of individuals counted. In the theory of probability this ratio is a measure of dispersion of a probability distribution or density. If individuals are dispersed randomly in the sample according to a Poisson distribution, the variance of the distribution of individuals is approximately equal to the average. In the case of an aggregate distribution, however, the variance is larger than average.

A ratio variance/mean greater than unity, thus indicating a deviation from randomness and a tendency to aggregation that will be greater with increasing ratio. This aggregation index is simple to calculate and there are also simple statistical tests to assess the significance of the deviation between the ratio variance / mean observed and the value associated with a random distribution. A deviation from random distribution can be tested by multiplying the ratio between the variance and the average for the number of samples minus one (n-1). This index is called the dispersion index (ID) and can be compared with the distribution of the chisquare (χ^2) with n-1 degrees of freedom. For more details on mathematical formulas see Selby (1965) and Cicchitelli (2004). A more general approach to the relationship between the mean and the variance is given by an equation known as Taylor 's Power Law (Taylor, 1961), for more details see Burgio et al. (1995); Pasqualini et al. (1997), and Furlan & Burgio (1999).

MATERIAL AND METHODS

The observations were made in the morning hours in the July-August 2011 and 2012. The sampling site was the seaside beach located near the mouth of the Fiumarella di Guardavalle River in the Catanzaro province (Lat. 38° 28.142'N, Long. 16° 34.926'E) (Fig. 1).

The sampling of adults of *C. littoralis nemoralis* was performed using the visual census method consisting in daily observations carried out in morning hours (7.45-10.30 a.m.) from 20th July to 10th August 2011 and 2012. Three transects (A, B, C) (Fig. 1), 400 meter long and 1.5 meter wide, were chosen after a preliminary investigation of the study area. The transect A is located north of the mouth, beside a tourist resort that increases the human-induced habitat alterations. The transect B is located south of the mouth where human activity is lower than in the transect A. The transect C is U-shaped and includes the river mouth where human activity is very low.

The distribution scheme of adults along the transects was evaluated applying the Dispersion Index (DI) (Cicchitelli, 2004): this index is directly proportional to the variance of a sample. A sample with a variance higher than the mean value may be defined as aggregate, while a sample with a variance lower than the mean may be defined as regular. A sample having higher value of DI may be defined as aggregate, a sample having lower values of DI may be defined as regular.

To quantify the spatial distribution of individuals, has performed the verification of the adaptation of the data collected in the Poisson model (random distribution), the model of the binomial (grouped distribution) and the Rectangular model (uniform distribution) were performed. For the correlation of data models (Poisson, Binomial and Rectangular), was chosen the χ^2 test . In case of significant values χ^2 was rejected the hypothesis of randomness in the Poisson model, or the hypothesis of aggregation in the case of the Binomial or uniformity in the case of the rectangular model, with $p < 0.05$). According to the χ-square test results, we may conclude that the observed distribution significantly deviates from the distribution model adopted. The numerical analysis of the data was performed with the program STATISTICA (StatSoft, 1999) .

The spatial distribution of larval burrows was investigated along the river on a surface of 100 square meters, 30 meters from the shoreline, where two water bodies are present: one with flowing water and another with stagnant water. The investigated area was partitioned in 100 cells 1x1 m (Fig. 2). The abundance of larval burrows was evaluated within any cell resulting in density values. The localization of any burrow was georeferred using QGIS. Geostatistical analysis was performed using the Minimum Distance Analysis algorithm from Processing plugin, thus being able to calculate the values of minimum and maximum distance of burrows for each cell. The investigated area was subdivided according to the soil surface wetness because this soil property contributes to the survival of eggs, facilitates the digging of larval burrows and prevents the dehydration of larvae. We defined the soil surface as wet when sandy grains may stay at rest like a solid and dry when sandy grains don't show this property.

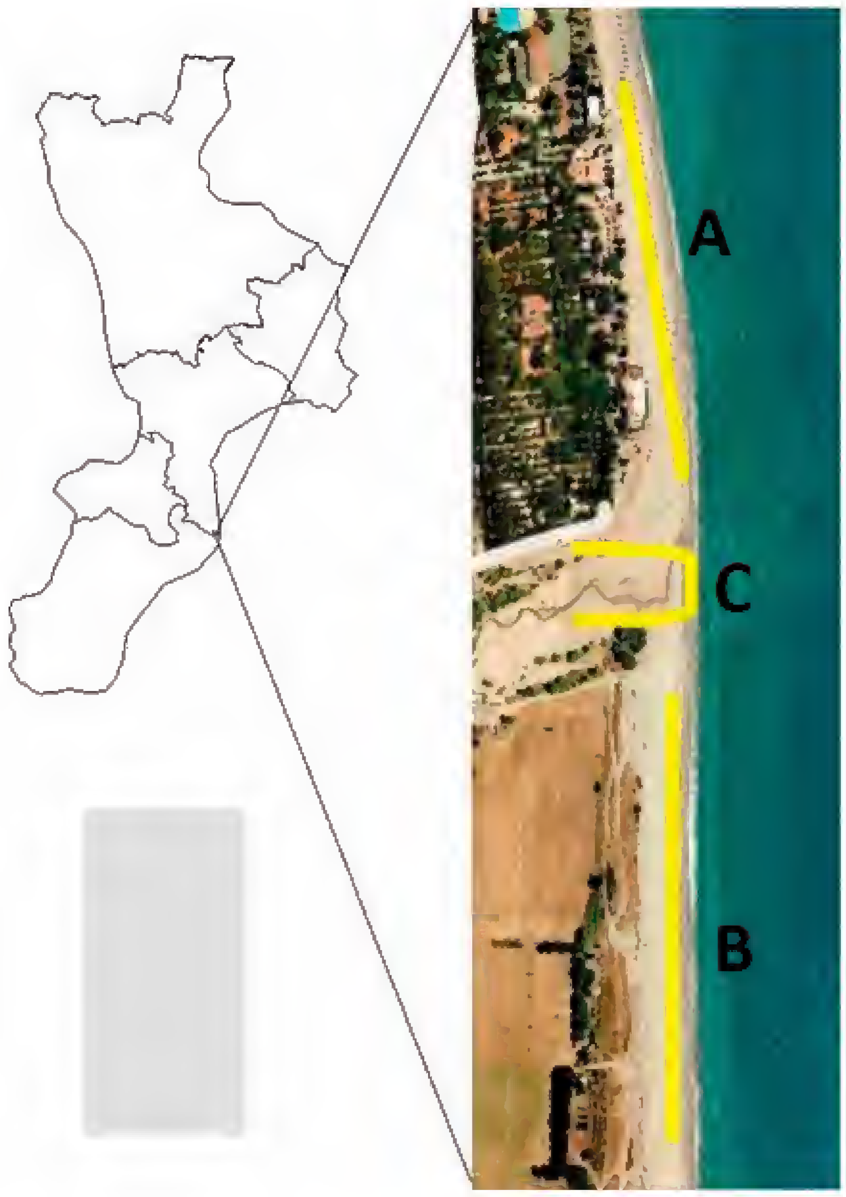

Figure 1. Location of study area. Letters indicate the sampled transects for adults sampling.

Figure 2. Location of the experimental plot for the study of larval distribution along the river.

RESULTS

A total number of 3,934 observations of adults was recorded for the study area subdivided in the sampled transects as follows:

Transects A: 1,015 observations (Mean = 36.3

individuals; SD = ± 4.00; variance = 18.56; DI = 13.98. Data trend shows that individuals have a regular distribution ($\chi^2$2.81 con p = 0,24).

Transects B: 1,382 observations (Mean = 49.4 individuals; SD = ±5.13; variance = 26.31; DI =14.39). Data trend shows that individuals have a regular distribution (χ^2 3.62, p = 0.06).

Transects C: 1,537 observations (Mean = 54.9 individuals; SD = ± 8.45; variance = 92.80; DI = 45.66). Data trend shows that individuals have an aggregated distribution (χ^2 2.93, p = 0.23).

265 larval burrows were found in the study area. They were found only on wet soil surface, as showed in figure 3. We found a significant difference of burrow density between the banks of flowing and stagnant water body (p<0.05). In fact, on the bank of flowing water body we recorded 85 burrows (4.25 ± 3.11 burrows/m^2), while on the bank of stagnant water body we recorded 180 burrows (16.36 ± 9.93 burrows/m^2). The minimum distance between larval burrows was 4.3 cm, the maximum within a cell was 72.6 cm, and the mean distance was 13.4 ± 10.6 cm (Fig. 3).

DISCUSSION AND CONCLUSIONS

The distribution of adults showed two clear patterns. They are less abundant in the more disturbed sand beach and more abundant where the human disturbance is weaker, with no significant differences between undisturbed sandy shore and river banks. Furthermore, they showed a gregarious habit only on the river banks and not on the coastal strips. Then, abundance depends on habitat disturbance but distributional pattern depends on habitat type. *C. littoralis* is mainly a predator, as all tiger beetles, and probably it uses the sand banks as hunting territory, where it preys visually by inspecting the entire soil surface. This behavior should result in a homogeneous distribution of adults on the investigated sand habitat. But both sexes show a gregarious behavior in habitats where a high trophic resource is disposable also for the alimentation of larvae such as the monitored river banks. This behavior was described also in riparian species of ground beetles (Zetto Brandmayr et al., 2004, 2005; Mazzei et al., 2006). This biotope could support the adult aggregation because vegetable material, such algae and aquatic plants are easily available for their prey. In fact, the high prey availability inhibits the aggressive behavior between adults within aggregation sites. In this investigation, the bank river seems to fulfill the optimal conditions for environmental and alimentary issues for adults and immature stages. Females search also for optimal soil moisture that prevents dehydration of eggs and larvae that complete their development cycle inside the sandy soil.

The larvae showed a clear preference toward wet soils, avoiding to dig burrows on the dry side of river banks. An optimal soil humidity rate ensures the survival of individuals inside the burrows and an easier maintenance of their rest site where they stay for prey. For larvae more than for adults, the soil moisture is a determinant parameter because it determines where to dig a burrow. The high density of burrows near to the stagnant water is probably due to a higher concentration of preys, mainly Diptera, in these sites compared to sites located along the flowing water. In fact, saprophagous dipteran communities are more abundant and species rich on decaying plant materials and around still waters.

In conclusion, the structure of *C. littoralis* populations is strictly dependent on food availability and habitat suitability and seems to be linked to the resources provided by the river mouth. The adult home range seems to be much larger than the reproduction sites, and wet and fine-grained sand banks along the stream mouths seem to be of outstanding importance for the conservation of this cicindelid species.

Studies on conservation biology of tiger beetles have become very common especially in the last 20 years. Pearson & Cassola (2007) assert their evolution is consistent with a historical model defined GCSPN (General Continuum of Scientific Perpectives on Nature, by Killingsworth & Palmer, 1992), that comprises sex steps from 1, "descriptive natural history" to 6, "Technical terminology and methods so refined that they now limit the audience that can fully comprehend it". This short study demonstrates that intermediate steps from 2, "simply experimental" to 5, "research teams and increasing evidence of socialization" are still of importance in defining measures for tiger beetle conservation, and that species ecology of too many cicindelid species is unsatisfactorily endeavoured.

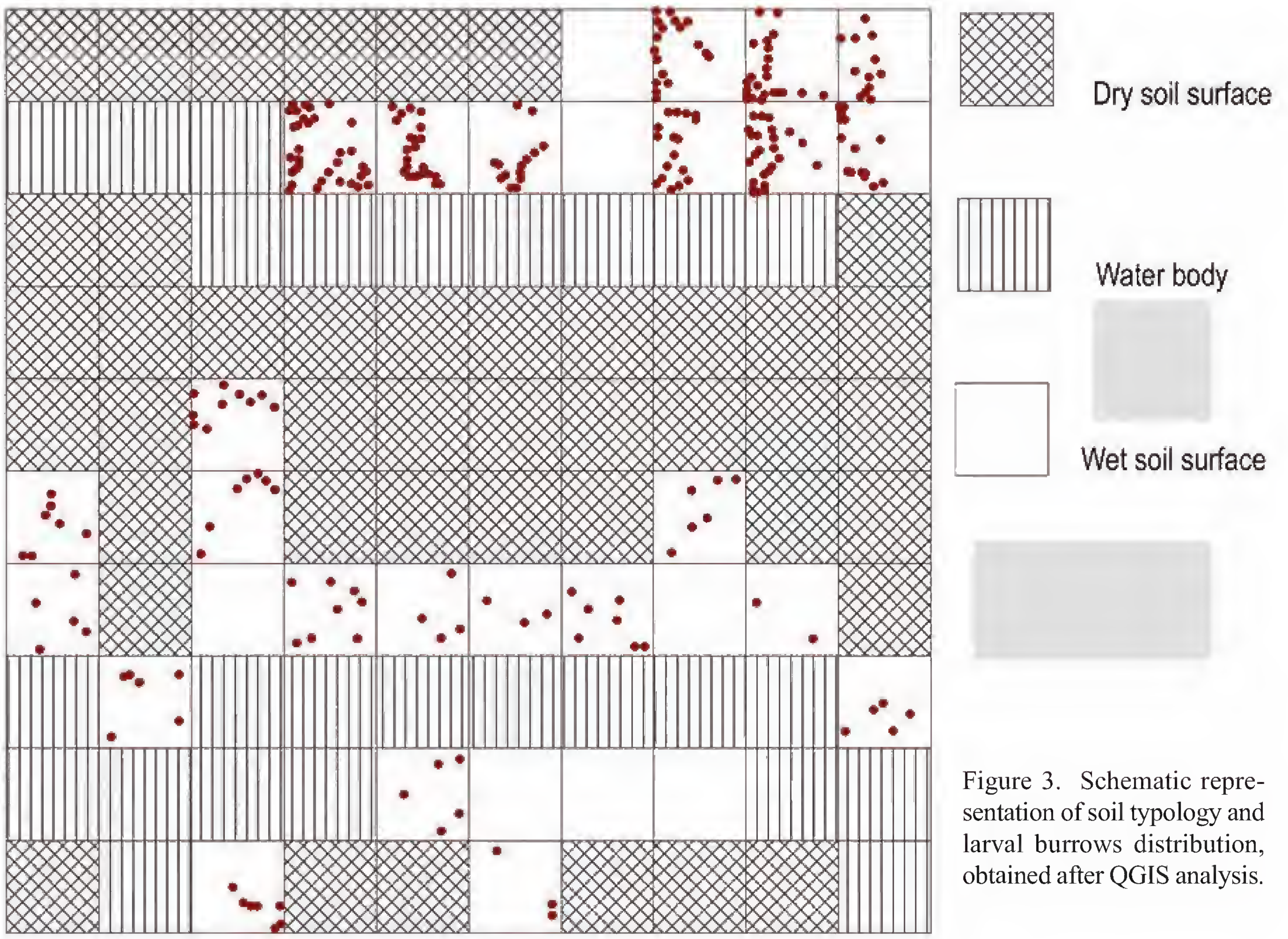

Figure 3. Schematic representation of soil typology and larval burrows distribution, obtained after QGIS analysis.

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Preliminary ecological studies on the Lepidoptera from Khajjiar lake catchment, Himachal Pradesh, India

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ABSTRACT

A study on the Lepidoptera from Khajjiar lake of District Chamba of Himachal Pradesh revealed the presence of 49 species of butterflies belonging to 41 genera and 10 families. Analysis of data revealed that family Nymphalidae and Satyridae (12 species each) dominated the Lepidoptera fauna of Khajjiar lake catchment, followed by Pieridae and Lycaenidae (6 species each), Hesperiidae (4 species), Papilionidae (3 species), Erycinidae and Danaidae (2 species each), and Acraeidae and Riodinidae (1 species each). Categorization of the species further revealed that of these 49 species, 5 were very common, 32 common, 5 uncommon and 7 were rare. Moreover, 3 species were listed in Indian Wildlife Protection Act (1972), *Lethe scanda* (Moore, 1857) and *Lampides boeticus* (Linnaeus, 1767) placed under scheduled II and *Castalius rosimon* (Fabricius, 1775) under scheduled IV of the Act. Our study revealed that forest area supports the highest diversity of butterflies followed by lake areas and human settlements.

KEY WORDS Butterflies; ecology; biodiversity; India.

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INTRODUCTION

A recent estimate shows the occurrence of about 142,500 species of Lepidoptera around the globe, but estimates within Lepidoptera from the Indian sub-continent revealed that the group comprises over 15,000 species and many more subspecies distributed over 84 families and 18 superfamilies (Alfred et al., 1998). In India nearly 1500 species of butterflies are reported (Gay et al., 1992). Many scientists have studied the butterflies from Himalayas including Moore (1882), Marshall & de Niceville (1890), Evans (1932), Talbot (1939; 1947), Wynter-Blyth (1940; 1945a, b; 1957), Mani (1986) and Thakur et al. (2002; 2006). Arora et al. (2005) listed 288 species from the recently created state of Himachal Pradesh distributed in 12 districts with altitudes ranging from 400-4500 m. However very few studies are there on the ecological aspects of the butterflies in Himachal Pradesh. Apart from Thakur et al. (2006) who have listed butterflies of Kalatop-Khajjiar wildlife sanctuary, there is little information about butterflies from Chamba district. However recently Singh & Banyal (2013) enlisted butterflies of Khajjiar along with insect fauna. But that work was focused only on presenting a checklist of insects and did not account the ecological aspects of butterflies. The area under investigation is one of the oldest conservation areas for wildlife in Himachal Pradesh and, being a favoured tourist destination, is also under remarkable anthropological pressure which may severely influence habitat conservation and egg laying habits of butterflies. Keeping this in mind we explored Khajjiar Lake to

assess ecological aspects of butterflies such as abundance, seasonal occurrence, habitat preference and conservation status. Besides, an effort was also made to identify the existing threats to the habitat of butterflies in the study area.

MATERIAL AND METHODS

Study Area. Khajjiar Lake "The Mini Switzerland of Himachal Pradesh" is situated in the western part of Chamba district of Himachal Pradesh. Khajjiar Lake lies 32°32´ North and 76°03´East about 1920 m above sea level between Chamba and Dalhousie (Fig. 1). The average depth of this lake is stated to be thirteen feet as per district gazetteer (Singh & Banyal, 2012). Khajjiar Lake has a clump of reeds and grasses exaggeratedly called an island in it. This lake is placed in the centre of large glade and is fed by slim streams. This glade is greenish in its turf and contains in its centre a small lake having an approximate area of 464.52 square meters. Khajjiar Lake has thick forest of Kala Top sanctuary (20.69 sq. km) surrounding the green grass. This small sanctuary lies in the catchments of the Ravi river, located in the western part of Chamba District. It is one of the oldest preserved forests of the state (notified on 01.07.1949). There is a 'golden' domed temple at the edge of this meadow, dedicated to the deity 'Khajjinag', from whom the area derives its name (Fig. 2). It experiences south-western monsoon rains in July-September and the average annual rainfall is about 800 mm. The climate of Khajjiar, summers being mild and winters cold and bitter, shows a temperature range from -10° C to 35°C. The vegetation consists of mature mixed Blue Pine (*Pinus wallichiana* A. B. Jacks.) and Deodar cedar forests (*Cedrus deodara* (Roxb.) G. Don), with some Green Oak and *Rhododendron* plants. Study area was broadly divided into three main types depending upon the vegetation and human intervention like dense forests, lake meadow and human settlements. Different butterfly species were sampled at regular intervals from all three localities.

Sampling of butterflies. Butterflies were sampled using the line transect walk method (Pollard &

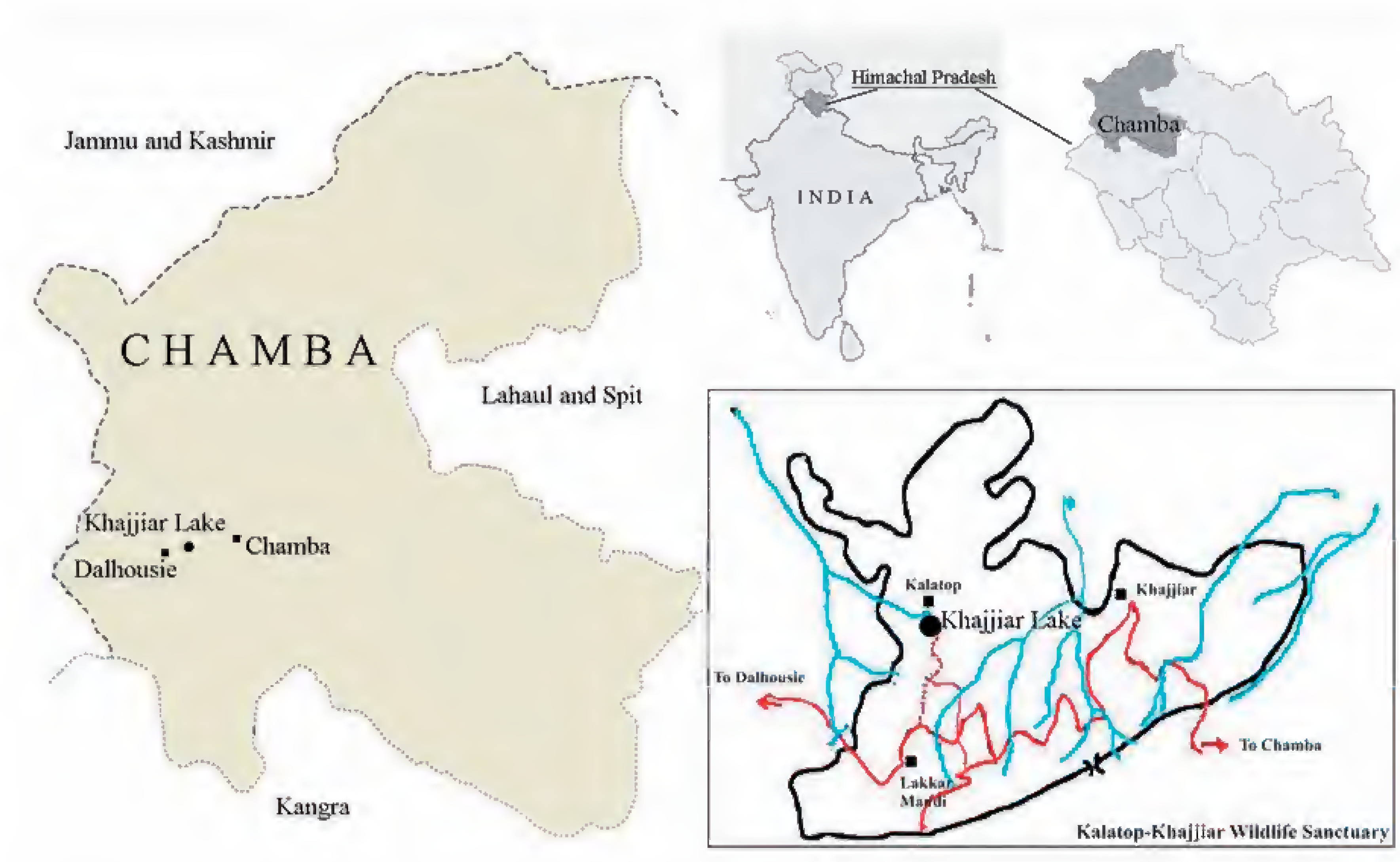

Figure 1. Study area: Khajjiar Lake, in the western part of Chamba district of Himachal Pradesh (India).

Yates, 1993). Six transects measuring 500 m each, were randomly laid for sampling (two in each site). Point counts were made after interval of 200 meters along each transect to record butterfly species and their number. All butterflies seen within two meters on either side of the transect were recorded. Transects were walked between 10:00 hrs and 13:00 hrs which corresponds to the peak activity period for most butterflies. Nylon net with long handle was used for sweeping free flying and free living butterflies. After collection specimens were put into killing bottles containing chloroform. These insects were transferred to paper envelops. Each envelop was numbered carefully and the details of specimen number, date, host etc. were written in a field notebook. Thereafter, insects were properly stretched and pinned by rust-free entomological pins. These stretched and pinned specimens were kept in wooden insect boxes in dry conditions providing naphthalene balls (Arora, 1990) to protect them from fungal infections and other attacks.

Butterfly Identification. Identification of species was done from description given by Marshall & de Niceville (1890), Evans (1932), Wynter-Blyth (1957). Some species were identified after comparison with reference collections housed at Indian Agriculture Research Institute (I.A.R.I.), New Delhi; High Altitude Regional Centre, Zoological Survey of India, Saproon, Solan; Himachal Pradesh and Forest Research Institute (F.R.I.), Dehradun. Dr. M.S. Thakur of Department of Biosciences, Himachal Pradesh University, Shimla was also consulted for authentication of identification.

Data analysis. Abundance status was assessed on an arbitrary frequency scale as: very common (VC), collected more than in eight spots from the three areas; common (C), collected from four to seven spots from the three areas; uncommon (UC), collected from two or three spots from the three areas; rare (Ra), collected from one spot from the three areas, according to Davidar et al. (1996).

RESULTS

Present study revealed the presence of 49 species of butterflies belonging to 41 genera and 10 families (Table 1). Analysis of data revealed that family Nymphalidae and Satyridae (12 species each) dominated the Lepidoptera fauna of Khajjiar area, followed by Pieridae and Lycaenidae (6 species each), Hesperiidae (4 species), Papilionidae (3 species), Erycinidae and Danaidae (2 species each), and Acraeidae and Riodinidae (1 species each) (Fig. 2). Analysis of these species for abundance revealed that of these 49 species, 5 were very common, 32 common, 5 uncommon and 7, namely *Parnassius hardkwickei hardwickei*, *Lethe insane insane*, *Lethe scanda*, *Ypthima ceylonica hubneri*, *Pseudergolis wedah*, *Issoria lathonia*, *Polytrema eltola*, were rare (Fig. 3). Moreover, three species were placed under Wildlife Protection Act (1972). These included *Lethe scanda* and *Lampides boeticus* placed under scheduled II and *Castalius rosimon* under scheduled IV of the Act.

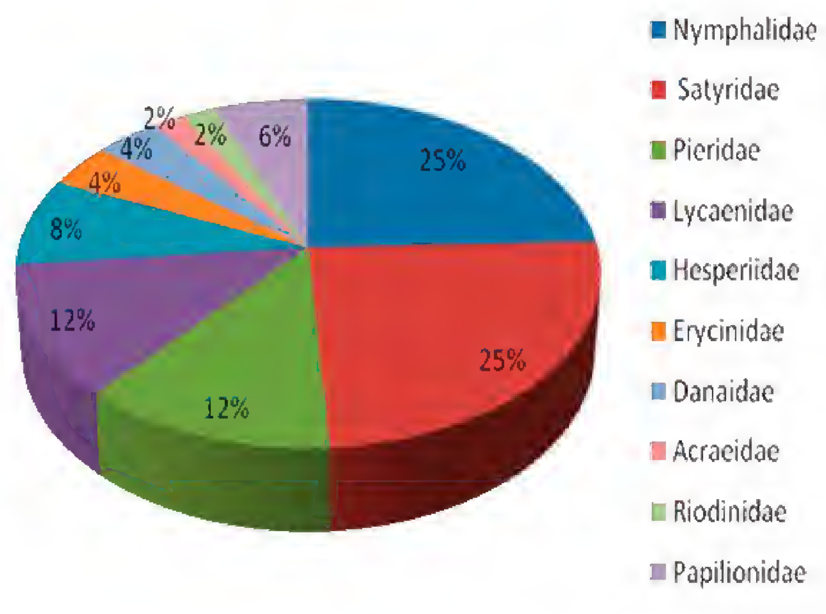

Figure 2. Lepidoptera diversity of the Khajjiar Lake,India.

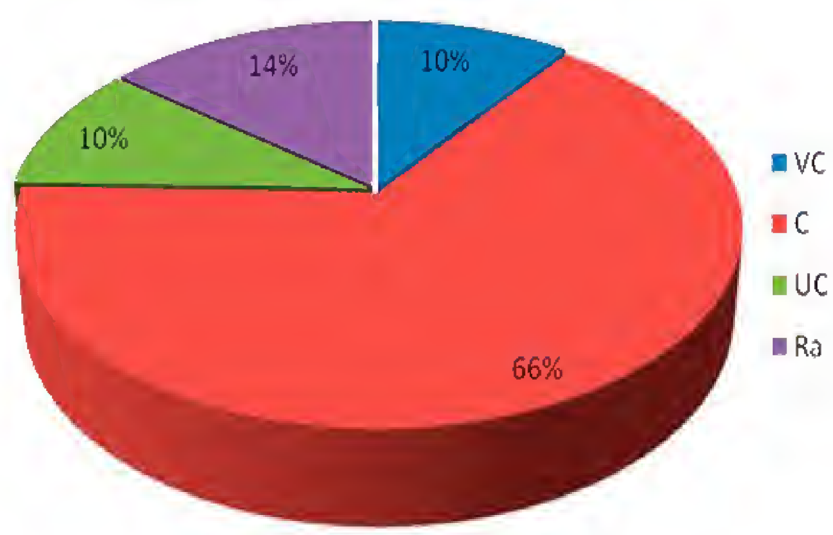

Figure 3. Lepidoptera abundance of the Khajjiar Lake, India; explanation in the text.

N.	Name of Butterfly	Family	Wing Size (in mm)	Conservation Status	Months of Dominance from-to
1	*Papilio protenor* Cramer, 1775	Papilionidae	100- 130	Common	March-September
2	*Papilio polyctor polyctor* Boisduval, 1836		90-130	Common	March-October
3	*Parnassius hardkwickei hardwickei* Gray, 1831		50-65	Rare	May-September
4	*Delias belladonna horsfieldi* (Gray, 1831)	Pieridae	70-96	Uncommon	April-July September-November
5	*Pieris canidia indica* Evans, 1926		45-55	Common	April-October
6	*Catopsillia crocale* Cramer, 1775		55-75	Common	May-October
7	*Gonepteryx rhamni nepalensis* Doubleday, 1847		60-70	Common	March-October
8	*Eurema hecabe fimbriata* (Wallace, 1867)		30-40	Common	April-November
9	*Colias electo fieldi* Menetries, 1885		42-45	Very common	February-November
10	*Danaus genutia* (Cramer, 1779)	Danaidae	70-78	Common	March-November
11	*Parantica sita sita* (Kollar, 1844)		85-105	Common	April-November
12	*Mycalesis perseus blasius* (Fabricius, 1798)	Satyridae	38-55	Very common	March-November
13	*Lethe insane insane* (Kollar, 1844)		55-60	Rare	May-October
14	*Lethe scanda** (Moore, 1857)		55-65	Rare	June-September
15	*Lethe verma verma* (Kollar, 1844)		55-60	Common	April-October
16	*Lasiommata schakra schakra* (Kollar, 1844)		45-60	Common	Apri-October
17	*Aulocera swaha swaha* (Kollar, 1844)		60-75	Common	May-September
18	*Aulocera saraswati saraswati* (Kollar, 1844)		60-75	Common	July-October
19	*Callerebia annada* (Moore, [1858])		55-70	Common	April-October
20	*Ypthima nareda nareda* (Kollar, 1844)		30-32	Common	April-October
21	*Ypthima ceylonica hubneri* Kirby, 1871		30-40	Rare	April-October
22	*Ypthima sakra nikaea* Moore, 1875		45-55	Very common	March-November
23	*Melanitis leda ismene* (Cramer, [1775])		60-80	Very common	March-November
24	*Athyma opalina* (Kollar, [1844])	Nymphalidae	55-70	Common	March-November
25	*Parathyma asura asura* (Moore, 1857)		65-75	Uncommon	July-August

Table 1. Check list and ecological data of the Lepidoptera from Khajjiar Lake, India (continued).

N.	Name of Butterfly	Family	Wing Size (in mm)	Conservation Status	Months of Dominance from-to
26	*Neptis mahendra* Moore, 1872		55-60	Common	April-October
27	*Neptis hylas astola* Moore, 1872		50-60	Common	March-October
28	*Pseudergolis wedah* Kollar, 1844		55-65	Rare	April-November
29	*Precis iphita* (Cramer , [1779])		55-65	Uncommon	Jan-December
30	*Cynthia cardui* (Linnaeus, 1758)		55-70	Common	April-November
31	*Vanessa indica* (Herbst, 1794))		55-65	Common	March-December
32	*Kaniska canace* (Linnaeus, 1763)		60-75	Uncommon	March-November
33	*Aglais cashmirensis* (Kollar, 1844)		55-65	Common	March-November
34	*Childrena childreni* (Gray, 1831)		75-100	Common	May-November
35	*Issoria lathonia* (Linnaeus, 1758)		55-60-78	Rare	February-October
36	*Acraea issoria anomala* Kollar, 1848	Acraeidae	45-65	Common	April-September
37	*Libythea myrrha* Godart, 1819	Erycinidae	45-55	Common	March-October
38	*Libythea lepita* (Moore, 1857)		55-60	Common	March-September
39	*Dodona durga* (Kollar, 1844)	Riodinidae	30-40	Common	March-October
40	*Pseudozizeeria maha* (Kollar, [1844])	Lycaenidae	20-30	Common	January-November
41	*Lampides boeticus** (Linnaeus, 1767)		24-36	Common	March-October
42	*Lycaena pavana* (Kollar, [1844])		37-40	Common	March-October
43	*Heliophorus sena* (Kollar, [1844])		28-33	Very common	March-October
44	*Castalius rosimon*** (Fabricius, 1775)		25-27	Common	January-November
45	*Rapala manea schistacea* (Moore, 1879)		30-33	Common	June-October
46	*Coladenia dan* (Fabricius, 1787)	Hesperiidae	35-45	Common	May-October
47	*Sarangesa purendra* (Moore, 1882)		28	Uncommon	May-June
48	*Polytremis eltola* (Hewitson, 1869)		32	Rare	March-November
49	*Borbo bevani* (Moore, 1878)		30	Uncommon	April-October

Table 1 (continued). Check list and ecological data of the Lepidoptera from Khajjiar Lake, India.

Maximum richness was observed in the forest area which is rich of trees with well developed undergrowth. Minimum richness was present in the human settlement of the study area which is a degraded habitat where continuous intervention of humans generated severe pollution. Intermediate values of species richness were observed in the lake meadow area.

DISCUSSION AND CONCLUSIONS

Khajjiar lake catchment, which is an important conserved area of Himalayas, supports a rich fauna of butterflies with 49 species. These records are in accordance with the previous study of Arora et al. (2005) who also recorded some butterfly species of conservation concern from the state of Himachal Pradesh. Similar studies were also conducted by Mehta et al. (2002) who studied butterflies of Pong Dam wetland in District Kangra (H.P.) and Thakur et al. (2006) who reported 50 species belonging to 37 genera under seven families; moreover distributional records of Rhopalocera from Pin Valley National Park were studied and 14 species belonging to 11 genera and four families were reported. Nymphalidae is the largest family of the butterflies in the study area represented by 12 species along with family Satyridae having the same number of species. Nymphalidae is the largest representative family of butterflies from India with 450 species (Varshney, 1993). This may be attributed to their polyphagous habits which probably helps these Lepidoptera to survive in a variety of habitats. Moreover, members of this species can forage in distant areas as they are active fliers.

Maximum numbers of species were observed from March to November and very few species were seen from December to February and only one species was noted in January in a human habitation far from frozen lake. Two species were present for a very short period of the year in the study area, i.e. *Parathyma asura asura* in July and August while the small-sized species *Sarangesa purendra* in May and June. Maximum abundance of butterflies in particular periods of the year (months) is related to seasonal variations and atmospheric temperature. From March to November the temperature of the area is favorable to lepidopterans. In the months from July to September Monsoon is active in this part of India which results in increased growth of various type of vegetation. Hence, during this time abundance of butterflies is more than in the months from December to February when climatic conditions in the area are very adverse. During this period the area is subject to heavy snow falls resulting in low temperatures and poor vegetation.

When relative abundance of these species was studied it was found that of these 49 species, 5 were very common, 32 common, 5 uncommon and 7 were rare. This shows that 10% species are very common, 66% species are common, 10% species uncommon and 14% are rare species of the total recorded species from the area. In addition, 3 species listed in Wildlife Protection Act (1972) viz., *Lethe scanda* and *Lampides boeticus* placed under scheduled II and *Castalius rosimon* under scheduled IV of the Act have also been reported from the Khajjiar area. The occurrence of three threatened species suggests the need of immediate need of implementation of strategies of sustainable conservation.

In this study it was revealed that maximum abundance was present in the forest areas of Khajjiar. Similar observations were made in previous studies on diversity and habitat preference of butterflies in various parts of India (Sreekumar & Balakrishnan, 2001; Ramesh et al., 2010; Sarma et al., 2012). Butterflies show distinct patterns of habitat utilization. The nature of vegetation is an important factor which determines the dependence and survival of a species on a particular habitat. Being highly sensitive to environmental changes, they are easily affected by even relatively minor disturbances in the habitat so much that they have been considered as indicators of environmental quality and are also treated as indicators of the health of an ecosystem. The presence of butterflies emphasizes availability of larval food plants. As stated before, most of the butterflies have specific habitat requirements, as females usually tend to lay eggs only on selective food plants occurring in the area (Thakur & Mattu, 2010).

With ever increasing number of tourists reaching Khajjiar every year the number of hotels in the area is increasing. This is good for general socio-economic development of the area but has adverse impacts on ecology. Many tourists visit deep in the forests and enjoy trekking in the hills. Hotels and tourists produce a large quantity of non-degradable garbage which accumulates in and around the lake

and also deep into the forest. These activities can affect sensitive microhabitat of butterflies. Present study revealed that Khajjiar Lake catchment area is very rich in lepidopteron fauna, which is depicted from the large number of variety of butterflies in term of large number of species. But at the same time 14% of the species comes under the category of rare species which means their specimens have been collected only from limited (single) place i.e. from grassland or dense forest or from human habitations. Additionally, 3 species were placed under Wildlife Protection Act (1972). Therefore this area needs intervention for implementation of measures of sustainable conservation.

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Biodiversity indices for the assessment of air, water and soil quality of the "Biodiversity Friend" certification in temperate areas

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ABSTRACT "Biodiversity Friend" is a standard certification developed in 2010 by World Biodiversity Association to evaluate the biodiversity and promote its conservation in agriculture. The procedure to obtain the certification considers the environmental impacts of the agricultural activities on the agrosystem and the biodiversity and suggests operational strategies to improve the environmental quality of the agriculture areas. The evaluation is referred to 12 actions related to low-impact methods of pest and weed control, reconstitution of soil fertility, rational management of water resources, diffusion of hedges, woodlands and nectariferous plants, conservation of agricultural biodiversity, soil, air and freshwater quality through Biodiversity Indices, use of renewable sources for energy supply, lower CO_2 production and CO_2 storage and other actions that may have beneficial effects on biodiversity.
The environmental conditions of the agrosystem are evaluated by biomonitoring of air, water and soil. The biodiversity of soil and aquatic macroinvertebrates and the biodiversity of epiphytic lichen communities decrease very quickly when the soil, water and air conditions are altered by different causes such as pollution, synthetic and organic pesticides, bad land use practices, etc. The protocol of the three indices of the standard certification "Biodiversity Friend": Lichen Biodiversity Index (LBI-bf), Freshwater Biodiversity Index (FBI-bf), and Soil Biodiversity Index (SBI-bf) are here presented in detail.

KEY WORDS biodiversity; bioindicators; pollution; certification; agrosystem.

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INTRODUCTION

Up to date, on the Earth about two million species have been recorded (Fontaine et al., 2012), but the naturalists estimate that the total number of species is at least 8.7 million (Mora et al., 2011), three-quarters of them concentrated in the tropical rainforests. So, we know only about one fourth of plant and animal species on our planet. Zoologists and botanists describe about 17,000 new species every year (Fontaine et al., 2012), but the destruction of tropical rainforests at a rate of several ten thousands sq km a year (Skole & Tucker, 1993; Katzman & Cale, 1990) determines the extinction of thousands

of species annually; therefore, the loss of biodiversity is one of the most important environmental emergencies today.

The recognition of such an emergency has led 150 countries to sign, at the Rio de Janeiro Earth Summit in 1992, the "Convention on Biological Diversity". With the aim of promoting sustainable development, the Convention recognizes that the protection of biodiversity is not concerned only to living organisms and their ecosystems, but it involves and affects the whole human community and its basic needs (the right to food, health, air, water and soil quality). Despite the Convention's member countries have met regularly to establish actions and strategies, the rate of biodiversity loss increased continuously. The minimum target set in the 6th Conference in Johannesburg on 2002, has been fixed in a meaningful reduction of the current rate of biodiversity loss at global, regional and national levels, within 2010 (Decision 6/26). Unfortunately, unsustainable patterns of production and consumption, lack of education and awareness about this problem at any level did not allow to get significant results: the rate of biodiversity loss has not been reduced; on the contrary, the destruction of rainforests is proceeding very quickly every day.

From a long time, the European Community recognized the conservation of biodiversity as a key objective of the strategy for sustainable development (Convention on Biological Diversity, 1992). The preservation of biodiversity is closely connected with other environmental emergencies, such as climate change and resources' availability, about which in the coming decades the fate of the entire human community will be played.

Biodiversity as a resource. Most people have a romantic vision of biological diversity, mainly linked to emotional and aesthetic criteria. Even though few people recognize its value, biodiversity is the most important resource of natural systems in the Earth. Therefore, its conservation is functional to real preservation of ecosystems, from which depend, directly or indirectly, all human activities. In essence, we can say that every living species is a potential resource, an option for the future, on the contrary every extinct species is a missed opportunity.

Today, at global level, the destruction and fragmentation of habitats, pollution, climate change, irrational exploitation of resources, human population growth and spread of alien species are the main threats to biodiversity (Convention on Biological Diversity, 1992).

Biodiversity is a fundamental resource for human beings, such as energy and water resources. The maintenance of high biodiversity in the environment must be an overriding objective for production activities, especially in the primary sector. The agrosystem can be considered as a man-controlled environment in which the coexistence of vegetal and animal species is not characterized by stable relationships between them; therefore it can not be considered a true ecosystem. However, it represents the best possible solution to assure environmental quality and food production. A modern farmer has to face the problem of how to encourage biodiversity in its farm and to manage the effects of a possible reduction since it was established the close relationship between the biological quality of the environment and the quality of products. The use of "good agricultural practices" to ensure conservation of soil fertility, correct water management, weed and pest control through environmentally friendly methods contribute to the maintenance of biodiversity in the agrosystems. Other actions such as the increase of hedgerows, wolds, wooded areas and nectar species, the leaving of necromasses and the use of multi-year rotations, increase biodiversity in the agrosystems, at the same time improving the quality of air, water and soil (Lowrance et al., 1986).

Supporting biodiversity in agrosystems. In this changing world, we are facing a strategic challenge for the future of the planet: to ensure, in terms of sustainability, the productivity of economic systems and the preservation of natural resources.

World Biodiversity Association, a non-profit organization since its foundation October 4, 2004 at the Museo Civico di Storia Naturale di Verona, has been engaged in studying and conserving biodiversity hot spots, in Italy and worldwide.

In the matter of environmental responsibility, World Biodiversity Association is moving for a long time to promote among the companies a greater consciousness of their role into the field of conservation and the sensitization of their clients to sustainability.

With the support of a team of naturalists, agronomists, foresters, and its International Scientific

Committee, WBA developed in 2010, a certification that, starting from the assumption of reducing the biodiversity losses in the cultivated areas, encourages farmers to increase biological complexity of the agrosystem, towards a real sustainability and quality of the crops. The new certification, named "Biodiversity Friend" (BF) is not merely confined to certify the engagement of the farm to a significant reduction of the biodiversity loss, but represents an incentive for the farm towards a progressive increase of biological diversity, that ultimately coincides with an improvement of the health and quality of the products. BF certifies that the production processes do not involve loss of biodiversity, and the certified company is constantly committed to improve the quality of the environment in which it operates.

The Biodiversity Friend standard. The Biodiversity Friend (BF) protocol considers the environmental impacts of the agricultural activities on the ecosystem quality and biodiversity. BF has the objective of defining a complete picture of the interactions of a product or service with the biological diversity of the territory. Moreover, the new protocol suggests operational strategies to improve the environmental quality, with the aim to reduce the impacts of the agricultural activities on agrosystems and their biodiversity.

Operative strategies are defined in 12 actions which are related to:

1) low-impact methods of pest and weed control (organic or integrated production)
2) low-impact methods for the reconstitution of soil fertility
3) rational management of water resources
4) presence of hedges, woodlands and dry stone walls/terraces
5) abundance of nectariferous plants
6) conservation of agricultural biodiversity
7) soil quality through the Soil Biodiversity Index
8) freshwater quality through the Freshwater Biodiversity Index
9) air quality through the Lichen Biodiversity Index
10) use of renewable sources for energy supply
11) moderate CO_2 production, CO_2 storage and low-impact manufacturing techniques
12) other actions that may have beneficial effects on biodiversity.

Each action corresponds with a score. The commissioner must obtain a minimum score of 60 out of 100 to be certified. To maintain the certification the commissioner must increase the biodiversity every year through effective actions that can be suggested by the evaluators and verified in the annual controls. When the farm get a score of 80 out of 100, no other improvement is requested (Caoduro & Giachino, 2012).

Since 2010 to the present day about 50 organic and integrated production farms have been certified "Biodiversity Friend". Many of them already placed on the market their products with the brand "Biodiversity Friend", to show the consumers their engagement in biodiversity conservation. In 2010 "Biodiversity Friend" obtained the patronage of the Ministry of Agricultural, Food and Forestry Policies of Italy. The brand "Biodiversity Friend" is exclusive property of the WBA and has been registered as an international trademark in Italy, European Union, China and U.S.A.

The Biodiversity Friend environmental quality assessment

The actions related to the environmental conditions of the agrosystem have a very high importance for the BF certification. They concern the assessment of the quality of the air, water and soil by using synthetic biomonitoring procedures based on methods recognized by scientific community. In the years 2009 and 2010 a group of WBA naturalists coordinated by Dr. Gianfranco Caoduro, under the supervision of the WBA Scientific Committee, developed different procedures for evaluating the complexity, in terms of biodiversity, of the soil and freshwater communities of temperate agricultural areas. In the same way, the Lichen Biodiversity Index (LBI), the most frequently used procedure to assess atmospheric pollution using bioindicators, has been modified to allow an easier application of the method. The operation allowed to identify three different procedures of the "Biodiversity Friend" protocol for the assessment of the quality of air, water and soil based on biodiversity indices. The biodiversity of soil and aquatic macroinvertebrates and the biodiversity of epiphytic lichen communities decrease very quickly when the soil, water and air conditions are altered by natural or anthropic causes such as pollution, synthetic and organic pesticides, bad land use practices, etc.

MATERIAL AND METHODS

The three indices of the standard certification "Biodiversity Friend" for temperate areas of North Hemisphere are represented by: Lichen Biodiversity Index (LBI-bf), Freshwater Biodiversity Index (FBI-bf), and Soil Biodiversity Index (SBI-bf).

THE LICHEN BIODIVERSITY INDEX OF BIODIVERSITY FRIEND (LBI-BF)

Lichens and air pollution in agriculture. Frequently air pollution is considered a problem related to industrialized and urban areas. However, in the last decades the impacts of agriculture on air quality has been recognized. Air pollutants like pesticides and ammonia substances can have negative effects also on freshwater, groundwater and soil (National Research Council, 2009). Many authors showed that air pollutants produced by agricultural activities have a reliable impact on epiphytic lichens (Alstrup, 1991; Brown, 1992; Loppi, 2003; Carrera & Carreras, 2011). Lichens are generally considered to be good indicators of air quality: altered composition of atmospheric gases is reflected in changes in epiphytic lichen communities. The sensitivity of lichens is particularly relevant to fungicides, but herbicides and insecticides also have an important impact on them. In particular, lichen species richness was demonstrated to be negatively influenced by the frequency of pesticide treatments (Bartok, 1999).

Lichen as bioindicators. Lichens are organisms formed by a symbiosis between a fungus and an alga. To date, more than 14,000 species of lichens have been described by lichenologists. Lichens can give excellent indications on the level of environmental alteration because their metabolism depends strictly by the air quality. The characteristics that make lichens excellent bioindicators of the air quality, both in urban and in rural areas, are: a) high capacity of absorption and accumulation of substances absorbed from the atmosphere; b) resistance to environmental stress; c) impossibility to get rid of the polluted parts; d) longevity and slow growth; e) high sensitivity to the pollutants.

In the evaluation of the air quality lichens can be used as bioindicators and bioaccumulators.

Frequently, a decrease in the number of lichen species is recorded together with a reduction of the number of specimens of each species. While morphological and physiological alterations are difficult to evaluate, the ecological variations allow to convert the lichen reactions into numeric values, related to different levels of air pollution. Generally, nearing the pollution sources, there is a progressive deterioration in lichen's health condition.

The first studies on lichen sensitivity to air pollution date back to the XIX century, but only since some decades they are used in large-scale biomonitoring. Recently many methods based on appropriate interpretation levels have been proposed. The most used procedure calculates the Lichen Biodiversity Index (LBI) based on the state of the lichen diversity in standard conditions, after a long exposition to atmospheric pollution and/or other kinds of environmental stress; the lichens considered for the index calculation are, essentially, the epiphytic ones. Specific indications on the sampling system and survey procedures of the lichen biodiversity are available on the Manual for the application of the index, published by ANPA (ANPA, 2001).

A synthetic method to evaluate the air quality of the rural areas is the use of the lichens as biosensors of phytotoxic gases (Nimis, 1999). The epiphytic lichen biodiversity is an excellent indicator of the pollution produced by air pollutants. By means of this approach it is possible to correlate different levels of environmental alteration to variations of the external aspect of the covering and floristic richness of the lichen communities. A phytotoxic agent, at determined concentrations, can cause the death of the lichens sensitive to it. As the sensitivity to the pollutants is related to the morphology of the lichen tallus, to its ecological, physiological and structural characteristics, the disappearance of the lichens from a polluted area is not simultaneous, but deferred in time: first the more sensitive species die and then the more resistant ones. Therefore, the floristic composition becomes an indirect measure of the concentration of pollutants in a certain place.

Lichens answer with a relative velocity to alterations of the air quality, but they can recolonize in few years industrial and urban environments if air quality conditions improve, as many European countries revealed. The studies of air quality through lichens found a large diffusion in Italy starting from the eighty years, at the same time with the resumption of the interests for the lichenological studies.

Many investigations were realized both in urban and in rural areas, in natural protected areas and in areas where the human activities are particularly intense.

The methodology adopted in Italy starting from the beginning of the 2000 years is indicated as "ANPA Method" (ANPA, 2001). This approach minimizes the subjective elements of the guide lines previously proposed in Italy and Germany, giving specific attention to the selection of the sampling sites, of the trees to be monitored and the position of the sampling grid.

This method estimates the state of the lichen biodiversity in standard conditions after a long exposition to air pollutants and/or other kinds of environmental stresses. It is important to specify that lichens considered in evaluation of biodiversity are essentially the epiphytic ones; this allows to limit the variability of the ecological parameters unrelated with pollution, such as base content or water capacity, very changeable in the lithic substrates.

The Lichen Biodiversity Index of "Biodiversity Friend"

According to the complexity of the ANPA method, which can be performed only by an expert lichenologist, Biodiversity Friend uses a simplified application of it, allowing to use the procedure also by non specialists. In the application of the "Biodiversity Friend" method the taxonomic identification of the lichen species is not necessary; the operator is required only to distinguish the major morphological differences among the species of the lichen community. The operator, therefore, identifies the "Species A", from the "Species B", from the "Species C" and so on. All other operations correspond exactly to the ones used by the ANPA Method. The use of the traditional sampling grid allows the calculation of a numerical index based on lichen diversity and on the frequency of the various species, through which it is possible to define the alteration level of the lichen community. The density of the sampling sites is calculated in relation to the extension of the total farm surface, as described in Table 1.

Each sample is formed by three trees (phorophyta) with the characteristics required by the protocol. The site must be located inside the farm lands, preferably in the central area. The operator must choose the three trees nearest to the farm center. If in the farm there are not trees suitable to be sampled the operator must search other trees in the peripheral zones. The geographic coordinates of the site must be reported on the sample form, together with a synthetic map with the location of the trees to make their finding easier in the following surveys. If the total farm surface is larger than 20 hectares and it is necessary to locate more than one site, these must be located at least at 150 m of distance among them. About the selection of the tree species, two groups can be distinguished according to the pH of the bark, as in Table 2.

Total Farm Surface	Number of samples
≤ 20 ha	One sample
20-200 ha	1 + (total surface – 50)/50 The result must be rounded to the inferior integer number
≥ 200 ha	3 + (total surface – 200)/100 The result must be rounded to the inferior integer number

Table 1. Number of air quality sampling sites in relation to farm surface.

Species with subneutral bark	Species with acid bark (to be preferred)
Acer pseudoplatanus	*Prunus domestica*
Acer platanoides	*Olea europaea*
Ceratonia siliqua	*Quercus petraea*
Ficus sp.	*Alnus glutinosa*
Fraxinus excelsior	*Castanea sativa*
Fraxinus ornus	*Quercus pubescens*
Juglans sp.	*Quercus cerris*
Populus x *canadensis*	*Betula pendula*
Sambucus nigra	*Prunus avium*
Ulmus sp.	*Tilia* sp.

Table 2. Tree species that can be used in biomonitoring of air quality by the LBI-bf.

For the biomonitoring the trees with a bark easily exfoliable (e.g. *Aesculus*, *Platanus*) must be excluded; the use of *Sambucus* and *Robinia* is not recommended for the high water tolerance of their bark. *Celtis australis* and *Populus alba* are not recommended because they maintain for a long time a smooth bark, poorly colonizable by lichens; *Fagus* is suggested only in mountain areas. Samples based on trees of different groups are not directly comparable. Only one tree species is to be used. When this is not possible, it is best to use another species of the same group. It is preferable to use species with acid bark, in particular, trees of the genus *Tilia* (Table 2). The sample trees must have the following characteristics: 1) the inclination of the trunk must not exceed 10° to avoid effects due to the excessive eutrophication of inclined surfaces; 2) circumference larger than 60 cm to avoid situations with pioneer lichens; 3) absence on the bark of evident factors of disturbance or pathologies.

The presence and frequency of the lichen species on the bark are detected by means of a sampling grid formed by a vertical ladder of 10x50 cm, divided in five subunities of 10x10 cm; the ladder must be applied to each of the four cardinal points, with the base at about 100 cm from the ground level. To exclude from the sample any unfit part of the trunk, a rotation up to 20° clockwise can be allowed.

Even if the lichen cover is high, the positioning of the grid in each cardinal point must avoid: decorticated or damaged portions of the trunk, portions with evident knots, portions corresponding to rainwater tracks, portions covered with more than 25% by bryophytes (however, also muscicolous lichens must be considered in the calculation, if they are present).

To allow the repetition of the survey, for every tree in the survey form must be noted: a) the exact location of the tree, using a geo-referenced system or a detailed map; b) the exact exposure (in degree) of each grid position; c) the height, from the ground level, of the grid base; d) circumference of the trunk in the middle of the grid.

All the lichen species present in each subunit must be recorded together with their frequency, calculated as number of squares in which each species is present (the frequency values of each species, therefore, vary from 0 to 5); if the same specimen of a certain species is present in more than one square, its frequency is equivalent to the number of squares in which it is present. The removal and damage of the lichens inside the grid area must be avoided to permit the repetition of the sample. Considering that the identification at specific level of each species can be difficult for a non-lichenologist operator, on the survey form is sufficient to determine the diversity of epiphytic lichens present on the tree specimen, by noting on the form: "Species A", "Species B", "Species C", etc., making sure that they are not damaged or underdeveloped specimens of species already present in the grid. In case of doubts in identifying a species, the operator can use the magnifying glass to confront at microscopic level the different morphologies and the camera for macro photography for a following identification. The value of lichen biodiversity of each sampled tree is obtained summarizing the frequencies recorded in each unit.

Calculation of the Biodiversity Lichen Index

The Biodiversity Lichen Index of the site is statistically determined on the basis of the values collected during the survey. The first step is to summarize the frequencies of the species recorded on each tree. As it is predictable a substantial growth difference among the sides of the trunk, the frequencies must be noted separately for each cardinal point. In this way, for each tree will be obtained four sums of frequencies (BLjN, BLjE, BLjS, BLjW). In each site the following operations must be realized:

1) for each tree the frequencies of all the lichen species detected are summed (in this way we have the biodiversity related to the single phorophyta);

2) all the frequencies gathered on each tree are summed and the total is divided by three (the number of phorophyta). In this way we obtain the Lichen Biodiversity Index of the site (LBI);

The Lichen Biodiversity Index of the site must be superior or equal to 45. In case of surveys to make in more sites (farms with total surface larger than 40 hectares), the total Lichen Biodiversity Index emerges by the sum of the indices of all sites, divided by the total number of sites. The ratio must be 45 or more, for an acceptable air quality.

Classes of lichen biodiversity

Generally, seven classes of Lichen Biodiversity are used, corresponding to the same number of air

quality levels. The reference scale under reported is the one calibrated for the Padan-Adriatic biogeographical area. For different areas a re-calibration of the classes is necessary.

- *Value of L.B. equal to 0*: corresponds to the so called "lichen desert", and therefore to a situation of very high alteration of the lichen community, corresponding to the worst level of air quality (very poor air quality).

- *Values of L.B. between 1 and 15*: are referred to zones with a high level of alteration of the lichen community. These zones have a very scarce air quality.

- *Values of L.B. between 15 and 30*: correspond to situations of medium alteration of the lichen communities. These zones have a scarce air quality.

- *Values of L.B. between 30 and 45*: are referred to zones with a low alteration level of the lichen communities and a low air quality.

- *Values of L.B. between 45 and 60*: are referred to zones with a medium level of naturalness of the lichen communities. In these areas the air quality is moderately good.

- *Values of L.B. between 60 and 75*: in these zones the lichen communities have a high level of naturalness. The air quality in these areas is good.

- *Value of L.B. more than 75*: in these zones the lichen communities have a very high level of naturalness. The air quality in these areas is very good.

According to the "Biodiversity Friend" procedure, the conformity to the action is reached by a value of L.B. equal or greater than 45, corresponding to an air quality quite good, good or very good, on the basis of the calibrated scale of the Padan-Adriatic biogeographic area (ANPA, 2001).

The survey can be performed during all the year.

Before starting the survey, the operator must have the following material:

- handbooks with epiphytic lichens identification keys
- survey form for LBI-bf
- Global Positioning System
- magnifying-glass (at least 10x)
- digital camera for macro-photos
- sampling grid formed by a vertical grid of 10x50 cm
- compass
- measuring tape (at least 3 m)

THE FRESHWATER BIODIVERSITY INDEX OF BIODIVERSITY FRIEND (FBI-BF)

There are several ways to make an environmental quality analysis of the freshwater and each of them can point out different aspects and critical points. It is possible to divide these methodologies in two main groups: the direct approaches, related to the physical-chemical analyses, and the indirect ones, represented by the biotic indices. Generally, the physical-chemical monitoring can be very detailed but it is related to simple problems and reveal single criticalities in a punctiform way. Chemical analysis targets only specific substances and it may miss intermittent or periodic pollutants, or substances outside the range of the analysis.

To analyze complex systems as the ecological net of a river or a stream, the biotic indices can be more suitable. The biomonitoring of the organisms living in waterways can reveal the effects of pollutants not detected by chemical analysis, as well recorded in modern literature since the proposal of the Beck's biotic index (Beck, 1955). The strategy of the biotic indices is based on the identification of macroinvertebrates, the sensitivity of which to water quality is well known; for this reason they are defined bioindicators. The community of the benthic macroinvertebrates in a water body is particularly adapted to be used as a source of bioindicators because it is easy to investigate, it is abundant and generally always available and it has moderate seasonal variations. Monitoring the animals that live in water bodies can reveal the effects of pollution not detected by chemical monitoring. For this reason the biotic indices had a very important role in the wide-ranging environmental analysis of the last half of the last century, till their recognition and standardization in the national and European regulations related to the monitoring and classification of the water bodies (Directive 2000/60/EC).

However, in the last years the standardized model of the Extended Biotic Index (Woodiwiss, 1964; 1978) has been improved by adding significant contributions. The E.B.I. works well if it is applied in well known areas, where the tolerance parameters of the single species are known, and if the investigation has a high detail from a taxonomic point of view, with the involvement of specialists in macroinvertebrates and hydrobiology. To bypass this methodological limit, and at the

same time to increase the systemic complexity of the analysis to the study of bioindicators, some authors suggested to reduce the taxonomic resolution, rewarding it with a more accurate description of the ecosystem and its functionality, using the "River Continuum Concept" (Vannote et al., 1980; Siligardi et al., 2007; or the Italian SEL in the D.M.391/2003).

As a further evolution of the biotic index methodologies, the Freshwater Biodiversity Index of "Biodiversity Friend" is proposed to evaluate the suitability of a water environment to host a rich biodiversity. This protocol adapts common used assessing methods to evaluate biodiversity in freshwater environments, detecting the diversification and stability of the biotic communities (Klemm et al., 1990; Rosenberg et al., 1997), relating them to the river continuum and to the functional parts of the hydromorphology.

Determination of the FBI-bf. An environment suitable to host many kinds of organisms should be primarily heterogeneous, with different survival strategies. Therefore, a general classification of the entire ecosystem functional to the water course, conditioning its dynamics, is necessary. The operator has to fill out a survey form in which different morphological and ecological parameters are listed. If the water body presents significantly diversified ecological conditions, the operator must fill out a different form for each riparian zone; the final score will be obtained as the mean of the final values obtained for each zone considered.

Hydro-morphological Assessment

Width. The width of a water body is very important considering that the most food sources of the refuge and reproduction sites of the aquatic fauna are located near the banks. The width of the bed must be evaluated in normal water conditions; the bed of the stream includes the part occupied by the water and a riparian strip lacking of vegetation, trees and shrubs that can not survive in conditions of frequent submersion and erosion of the substrate caused by high floods.

During periods of low floods, a part of the bed can be colonized by pioneer herbaceous vegetation. Therefore, the operator must observe carefully the banks to locate the real width of the water body. The width will be evaluated transversally, from the extreme margins of the bed, in normal water conditions.

If the banks and the bed are completely overbuilt or if the flows are regulated, involving the drainage of the water body for more than three months in a year, or the bed is dredged more than twice a year, the water body must be considered "artificial".

Fluvial morphology. Dikes and canalization and flood-relief works artificially modify the water bodies to have as less impact as possible on the human activities, to prevent overflows and bank erosion. In many agricultural areas is very difficult to keep rivers in their natural conditions, especially in Europe where anthropization and urbanization are widely spread (U.N., 2012). On the contrary, a strong artificial management leads to an homogenization of the fluvial structure, reducing the capacity of the water bodies to support complex biotic communities. A compromise is, however, possible.

A straight channel, completely artificial, with overbuilt banks offers very few food sources and refuge sites; it will be colonized, in the best case, only by few and very resistant organisms. A more sinuous and irregular course with natural banks, at least in some reaches, on the contrary, can transform radically a little agricultural channel in a wetland of great interest for the freshwater flora and fauna.

Hydrological regime. Water flow variations are natural and related to seasonality; they can support the alternation of different host species and increase aquatic biodiversity. A constant natural flow, determined by a well-structured hydrological network, on the other hand, even guaranteeing more stability and continuity to some species, can reduce the possible strategies.

Alterations to the natural hydrological regime such as water withdrawals for agricultural, hydroelectric or civilian uses can influence significantly the functionality of the water body, causing temporary shallows incompatible with the life cycles of many organisms; also the artificial irrigation ditches can be considered in this category (Bunn & Arthington, 2002; Ferrington & Sealock, 2005).

The flow variations must not be evaluated by the size of the wetting bed at the moment of the survey, but they must be deduced from the extension and complexity of the perifluvial vegetation and, even-

tually, by information given by other sources of monitoring (e.g. Literature, recording stations, etc.).

<u>*Riparian vegetation.*</u> The perifluvial vegetation, besides conditioning the position and extension of the shaded areas, influences the riparian morphology by creating niches and sites adapted to host the aquatic fauna and produces the most of its food sources. If, in absence of riparian vegetation, only few particularly resistant species can survive, every increase in terms of diversity and complexity of the riparian communities will be followed by an increase of the aquatic animal species. Compiling the survey form, different categories can be added together, if they are present (e.g. trees, shrubs and herbs). Only hygrophilic and riparian species can be considered in the survey; exotic species and not riparian herbaceous vegetation must not be considered.

Taxonomic diversity and pollution tolerance

After the hydro-morphological assessment of the water body has been surveyed, the operator evaluates the diversity of the aquatic biocenosis by a direct sampling. The "Biodiversity Friend" procedure does not consider the species as in the classic taxonomy but as morphotypes, as a compromise between a simple evaluation suitable for non-taxononomists and an accurate quantitative evaluation of species diversity.

The morphotypes are here considered as groups of organisms which at macroscopic level are characterized by similar shapes. It is not important to define the taxonomic level: e.g. a sample of two species of Plecoptera, one species of Amphipoda and three different genera of Mollusca corresponds to six morphotypes.

However, the identification of a morphotype needs a good knowledge of the aquatic fauna, considering that many individuals of different species can look identical to an untrained eye. An adequate training, even if not at specialistic level, will be necessary to recognize differences in the number of appendixes, the different form or position of bristles or hooks and so on.

The number of the morphotypes gives a direct evaluation of the biodiversity richness and complexity of the communities. The dominance of few morphs indicates a scarce species richness, the heterogeneity of the morphs, indicates good species richness. If an healthy aquatic environment can host a rich variety of organisms, the presence of a pollutant can limit this condition. Each species, according to scientific literature (e.g. Mandaville, 2002; see Table 3), has a certain tolerance to pollution, but it is possible to identify a predisposition to tolerance also at a higher taxonomic level, obviously arriving at some detail compromises which are considered acceptable by many authors (Olsgard et al., 1997). If it is not infrequent to find tolerant invertebrates in low polluted sites, the opposite is not true.

Therefore, the presence of at least two bioindicators belonging to groups particularly sensitive to pollution is here considered as a significant indication to evaluate the minimum quality of the aquatic environment. In the survey form the two lower values are identified to define the pollution tolerance, corresponding to the rounded down mean of these two values.

Survey: materials and methods

Before the biological survey, the monitoring procedure of the FBI-bf provides also the analysis of the main physico-chemical parameters of the freshwater measured by portable instruments. In particular must be surveyed and reported on the FBI-bf form the following parameters: temperature, pH, electric conductivity and dissolved oxygen. These additional information can be useful to understand the reason for eventual discrepancies between an apparently good environment and a rich variety of organisms and suggest the commissioner effective action to reduce the pollution.

Sampling of water macroinvertebrates is performed with a collecting-net for aquatic invertebrates (grid 500 µm), according to the procedure proposed by the British Standards Institute (ISO 10870: 2012). In some circumstances the identification of aquatic invertebrates is possible also from the bank, investigating the lower surface of rocks and rubbles. Before sampling with the collecting-net, the operator must verify the activity of surface insects, collect by hands the stones and submerged wood of the bottom for at least two minutes. All the groups of macroinvertebrates observed during these surveys will be reported on the FBI-bf form. The sample with the collecting-net must begin from the most downstream point of the water body, proceed-

MACROGROUPS	TROPHIC GROUP	POLLUTION TOLERANCE
Plecoptera	Shredders/Grazers/Predators	2
Ephemeroptera	Collectors	3
Tricoptera	Collectors/Grazers/Shredders	4
Megaloptera	Predators	4
Platyhelminthes	Collectors	4
Coleoptera (larvae)	Predators/Grazers/Shredders/Collectors	4
Heteroptera	Predators	5
Odonata Anisoptera	Predators	5
Odonata Zygoptera	Predators	8
Arachnida Hydracarina	Predators	6
Diptera (larvae)	Collectors/Grazers/Predators/Shredders	6
Crustacea Amphipoda	Collectors	5
Crustacea Decapoda	Collectors/Grazers	6
Crustacea Isopoda	Collectors	8
Mollusca	Collectors/Grazers	7
Oligochaeta	Predators	7
Hirudinea	Predators/Collectors	9
Nematoda/Nematomorpha	Predators	8

Table 3. Trophic characteristics and synthetic index of pollution tolerance (from Mandaville, 2002 modified) of the most common types of freshwater macroinvertebrates.

ing upstream; in this way the aquatic environment is not disturbed before the sampling. The collecting-net must be placed against the flow; the operator's feet and contemporarily the aquatic net can be used in deeper water bodies to move the ground debris and drive out burrowers and climbers. In these conditions the net must be held vertically, in opposition to the water flow, downstream the operator's feet.

After 3-4 minutes of sampling, the material collected by the net is put into a little white tank and the operator will begin the identification of the invertebrates morphotypes, with the aid of a magnifying glass. In case of uncertain identification, small size invertebrates can be collected by means of entomological pincers or little brush and put in a test-tubes with ethyl alcohol 70% to be identified later.

After having finished the sample the Freshwater Biodiversity Index of the site can be easily calculated by summing all the scores obtained in each section of the form: hydromorphology, taxonomic diversity and pollution tolerance. To have acceptable conditions of biodiversity the result must be 30 or more.

The survey must be done in low or normal water conditions coming from decreasing flows, from spring to autumn. Most benthic invertebrate populations are subjected to seasonal life cycles and this should be considered in the results. The sampling

can give results not reliable in the following situations:

- during or immediately after flood events (it is recommended to wait at least two weeks to allow the recolonization of the substrates);
- during or immediately after periods of drought (it is recommended to wait at least four weeks);
- impediments caused by environmental factors such as the high turbidity of water.

The samples must be done in a congruous number, also in relation with the extension of the superficial water grid of the farm or in near areas, on the base of the Table 4.

Total Farm Surface	Number of samples
≤ 20 ha	Two samples
20-200 ha	2 + (total surface – 40)/50 The result must be rounded to the inferior integer number
≥ 200 ha	5 + (total surface – 200)/100 The result must be rounded to the inferior integer number

Table 4. Number of water quality sampling sites in relation to farm surface.

Completed the samples, in relation to the extension of the farm surface, the general Freshwater Biodiversity Index of the farm can be easily calculated by summing the scores obtained in each survey form. The mean of the results must be 30 or more, for acceptable condition for biodiversity.

Before starting the survey, the operator must have the following material:

- handbooks with aquatic macroinvertebrates identification keys
- survey form for FBI-bf
- digital portable thermometer
- digital portable pH meter
- digital portable EC meter
- dissolved oxygen test kit
- aquatic net (ISO 10870:2012)
- magnifying glass 10x
- little white tank 30x40 cm
- lattice gloves
- entomological pincers
- test-tubes with ethyl alcohol 70%
- digital camera for macro photos
- Global Positioning System

THE SOIL BIODIVERSITY INDEX OF BIODIVERSITY FRIEND (SBI-BF)

The soil can be considered an ecosystem formed by a complex mixture of mineral particles, water, air, organic matter and living organisms; being the basic factor of the agricultural production, it is one of the most valuable natural resources on the Earth. A large part of Europe's land is affected by soil deterioration due to erosion, compaction, contamination, loss of organic content and change in land use (Jones et al., 2012). To be sustainable, agriculture in the future must adopt a careful soil management.

The utilization of the soils for the purpose of producing food needs a very high level of maintenance of the resource. The soil quality is traditionally evaluated by means of physical, chemical and microbiological indicators. Some methods based on the use of soil microarthropods in evaluating the soil quality were proposed in the past by different authors. In fact, many endogean animals show high sensitivity to land management practices and can be easily related to the soil ecosystem functions (Black, 1965; Menta, 2008).

The evaluation of the state of natural integrity, or alteration, of the edaphic ecosystem can be effectively realized through the study of the soil fauna. The edaphic or subterranean animals living in the soil have a close series of relationships among them and interact continuously with the physical environment. Any alteration of this environment is "registered" by the soil community which, therefore, can be used as indicator of the variation of the natural conditions (Giachino & Vailati, 2005; 2010).

Considering the complexity of soil communities, in qualitative investigations are usually examined some groups of animals that have species with fundamental requirements to be considered good biological indicators: to be assessable, to be easily determined and to be sufficiently known from an ecological and biogeographic point of view.

Coleoptera Carabidae and Staphylinidae, Opilionida, Lumbricidae and Enchytreidae were the groups more frequently used in the past for investigations of this kind (Brandmayr et al., 2005). But the application of these procedures were often limited by the difficulty of classification at species level, that requires the work of specialists in zoology.

The method of evaluation of the biological soil quality in relation to the presence of edaphic microarthropods, was proposed by Parisi in 2001 (QBS-ar, Qualità Biologica del Suolo-Arthropoda), initially with the aim to develop a procedure able to characterize the maturity of woodland soils. Using the ecological concept of Biological Form (or ecotype), similar to Sistematic Unit in the Extended Biotic Index, and analyzing the morphological and functional convergence among the soil microarthropods, Parisi (2001) assigned a different importance to each group characterizing the structure of the soil community, defining the so called ecomorphological indices (EMI).

The method of the standard "Biodiversity Friend" is based on the analysis of soil samples in which the presence of the animal taxa (Table 5) is detected to determine the Soil Biodiversity Index (SBI-bf); the presence of each group is recorded with a score in the proposed form. In comparison with the QBS-ar method, in addition to the Arthropoda, Mollusca and Annelida have been considered. These groups have a fundamental role in the dynamics of the edaphic ecosystem (Liu et al., 2012).

PHYLUM	CLASSES	ORDERS (or families)	SCORE
Mollusca	Gastropoda	Pulmonata and terrestrial Prosobranchia	10
Annelida	Oligochaeta	Enchytraeidae	10
		Lumbricidae	25
Arthropoda	Aracnida	Pseudoscorpionida	20
		Palpigrada	20
		Araneae	5
		Opilionida	10
		Acaroidea	25
	Crustacea	Isopoda	10
	Myriapoda	Diplopoda	15
	Insecta	Chilopoda	15
		Pauropoda	20
		Symphyla	20
		Collembola	25
		Protura	20
		Diplura	20
		Thysanura	10
		Orthoptera (Gryllotalpidae and Gryllidae)	10
		Dermaptera	5
		Blattodea	5
		Embioptera	15
		Psocoptera	5
		Coleoptera	10
		Hymenoptera (Formicidae)	5
	Larvae of Holometabola	Diptera	10
		Coleoptera	10
		Other Holometabola	5

Table 5. Table for the determination of the Soil Biodiversity Index of "Biodiversity Friend" (SBI-bf)

BIODIVERSITY FRIEND CHECKLIST

SURVEY FORM OF THE LICHEN BIODIVERSITY INDEX (FORM LBI-bf)

Farm ______________ Locality ______________ Province ______

Date ______________ Operator ______________

Site UTM Coordinates: ______________ Altitude m a.s.l. ______

Lichen Biodiversity Index-bf: ________

List of the species	**Code of the phorophyta and exposition**												**Frequency**
	1				2				3				
	N	E	S	W	N	E	S	W	N	E	S	W	
TOTAL													
LBI													
LBI TOTAL													

NOTES:

Figure 1. Survey form of the Lichen Biodiversity Index (Form LBI-bf).

BIODIVERSITY FRIEND CHECKLIST

SURVEY FORM OF THE FRESHWATER BIODIVERSITY INDEX (FORM FBI-bf)

Farm ______________________ Locality ________________________________ Province _______

Date ________________ Operator ______________________________________

Site UTM Coordinates: ____ Altitude m a.s.l. _______ _______

Length of the considered reach: _____ m **Freshwater Biodiversity Index-bf**: _____

H_2O physico-chemical parameters: **t** ___ °C **pH** ___ **Elect. cond.** ___ µS/cm **dissolved O_2** ____ mg/l

1) HYDROMORPHOLOGY					
Category	**Score: 5**	**Score: 3**	**Score: 2**	**Score: 0**	**Total**
Width	>6 m	2-6 m	<2 m	artificial	
Riparian vegetation	hygrophilous herbaceous	arbustive riparian	arboreous riparian	absent or not functional	
Hydrolog. Regime	seasonal natural	constant natural	seasonal altered	Artificial	
Fluvial morphology	heterogeneous	irregular	simple	canalized	
				Final score (1)	

BIOINDICATORS GROUPS	**NUMBER OF MORPHOTYPES**		**POLLUTION TOLERANCE**
Plecoptera			2
Ephemeroptera			3
Trichoptera			4
Megaloptera (Sialidae)			4
Platelmintes (planarian flatworms)			4
Coleoptera			4
Hemiptera			5
Odonata: Anisoptera			5
Odonata: Zygoptera			8
Hydracarina			6
Diptera			6
Amphipoda			5
Decapoda			6
Isopoda (Asellidae)			8
Bivalvia/Gasteropoda			7
Oligochaeta			7
Hirudinea			9
Nematoda/Nematomorpha			8
TOTAL MORPHOTYPES	(*)	**MEAN OF THE TWO LOWER VALUES OF TOLERANCE**	(**)

2) TAXONOMIC DIVERSITY					
Category	**Score: 25**	**Score: 15**	**Score: 5**	**Score: 0**	**Final score (2)**
N. morphotypes (*)	heterogeneous distribution (>20)	light dominance (9-20)	heavy dominance (4-8)	dominance/complete absence (0-3)	

3) POLLUTION TOLERANCE					
Category	**Score: 25**	**Score: 15**	**Score: 5**	**Score: 0**	**Final score (3)**
Mean tolerance (**)	0-2	3-4	5-7	8-9	

Index FBI-bf (1+2+3)		**Scarce 0-29**	**Acceptable 30-44**	**Good 45-64**	**Excellent >65**

NOTES:

Figure 2. Survey form of the Freshwater Biodiversity Index (Form FBI-bf).

BIODIVERSITY FRIEND CHECKLIST

SURVEY FORM OF THE SOIL BIODIVERSITY INDEX (FORM SBI-bf)

Farm ______________________ Locality ________________________________ Province _______

Date _________________ Operator ______________________________________

Site UTM Coordinates: ____ Altitude m a.s.l. ______

Meteo conditions: □ clean □ moderately cloudy □ cloudy t = ___ °C **Soil Biodiversity Index-bf**: ___

Soil (texiture): □ clay □ silty-clay □ silt-loam □ loam □ sandy-loam □ sandy skeleton % ___

PHYLUM	CLASSES	ORDERS (or families)	Score	Presence
Mollusca	**Gasteropoda**	Pulmonata and Prosobranchia	10	
		Enchytraeidae	10	
Annelida	**Oligochaeta**	Lumbricidae	25	
		Pseudoscorpionida	20	
		Palpigrada	20	
		Araneae	5	
	Arachnida	Opilionida	10	
		Acaroidea	25	
	Crustacea	Isopoda	10	
		Chilopoda	15	
	Miriapoda	Pauropoda	20	
		Synphyla	20	
		Diplopoda	15	
Arthropoda		Collembola	25	
		Protura	20	
		Diplura	20	
		Thysanura	10	
	Insecta	Orthoptera (Gryllotalpidae and Gryllidae)	10	
		Dermaptera	5	
		Blattodea	5	
		Embioptera	15	
		Psocoptera	5	
		Coleoptera	10	
		Hymenoptera (Formicidae)	5	
	Larvae of	Diptera	10	
	Holometabola	Coleoptera	10	
		Other Holometabola	5	
			Final score SBI-bf	

NOTES:

Figure 3. Survey form of the Soil Biodiversity Index (Form SBI-bf).

Survey methodology of the SBI-bf

One of the most common methods of collecting soil macroinvertebrates is through the "free hunting" (with or without aspirator). During this operation the exploration of the muscicolous, saproxylic and lapidicolous enviroments must be done. In the "Biodiversity Friend" survey the collecting of the specimens is not required; the simple observation of the animals will be recorded on the survey form. By describing carefully the content of the samplings is possible to evaluate the Soil Biodiversity Index and, therefore, the variety of the soil community of a certain soil. The synthetic value obtained is used in the "Biodiversity Friend" checklist to evaluate the conditions of the cultivation substrate.

According to the "Biodiversity Friend" standard, the technique used for the soil survey is based on the use of the entomological litter reducer. The survey is made by digging with a spade a volume of soil of about three square decimetres. The hole must have a depth of about 25-30 cm. The soil is collected and put into an entomological litter reducer with a sieve having meshes of 10 mm. The material obtained is sieved again through another sieve with 4 mm mesh. The particles of soil must be sieved on a white square piece of cloth (1x1 m large). The large soil particles collected in the sieve are put in a corner of the cloth.

At this point, the operator begins the identification of the invertebrates, directly or with the help of a magnifying glass. Little by little the different taxa of invertebrates are found and identified; their presence is noted on the survey form. In case of uncertain identification, for large size organisms (more than 5 mm) a camera can be used, while small size organisms can be collected by means of entomological pincers or little brush and put in a test-tubes with ethyl alcohol 70% to be identified successively.

Before starting the survey, the operator must have the following material:

- handbooks with invertebrate identification keys
- survey form for SBI-bf
- Global Positioning System
- entomological litter reducer
- work gloves
- portable spade
- sieve with 4 mm mesh
- magnifying glass 10x
- white cloth 1x1 m
- entomological pincers
- aspirator
- little brush with soft bristles
- test-tubes with ethyl alcohol 70%
- digital camera for macro-photos

The samples must be collected in workable (in "tempera") soil; too dry or too rainy periods must be avoided. The most favourable seasons are spring and early autumn. However, surveys must be realized with sunny and warm conditions (more than 18° C), to stimulate the soil fauna to move after sieving.

If the surveys are made during a droughty spring or autumn, with dryness of the superficial soil layers, the samples can be taken sieving the soil collected from around the roots of cultivated or spontaneous plants of the crop. The most advisable thing is to collect the whole plant and insert it with all its roots and soil clod in the litter reducer. In the driest periods the pedofauna looks for moisture in the deepest layer of the soil or near the root apparatus of cultivated or spontaneous plants.

In the same way, further investigations by hand-collecting can be made under stones deeply buried in the soil, if they are present in the crop.

At the end of the survey, the operator sums all the scores registered on the form SBI-bf. According to the Soil Biodiversity Index a biologically active soil must reach a total score of 100 or more. The surveys must be done in an adequate number of samples in relation to the extension of the farm surface. The number of samples on each more representative crop of the farm must be proportionally related to the extension of the farm (Table 6).

After having finished all the samples, in relation to the extension of the farm surface, the Soil Biodiversity Index can be easily calculated by summing the scores of each samples, divided by the total number of samples. The ratio must be 100 or more, for a farm with soils of acceptable quality. Besides the surface extension, the definition of main or more representative crops considers also the criticality in terms of the use of resources. The woodlands must be considered as crops if they are managed using various silvicultural systems.

Total Farm Surface	Number of samples
≤ 20 ha	Three samples distributed on the main or more representative crops
20-200 ha	3 + (total surface – 20)/40 The result must be rounded to the inferior integer number. The samples must be distributed in the 4 main or more representative crops
≥ 200 ha	7 + (total surface – 100)/100 The result must be rounded to the inferior integer number. The samples must be distributed in the 5 main or more representative crops

Table 6. Number of soil quality sampling sites in relation to farm surface

DISCUSSION AND CONCLUSIONS

The three indices here presented are (for survey forms see figures 1-3) original contribution based on existing and largely used method of assessing biodiversity and the quality of different environments adapted to the operative methodology of the certification protocols. The procedures here proposed are the result of a rational compromise between a detailed and complete anal-ysis and the need of fast assessing protocols for non-specialist operators. To reduce the potential errors and approximations due to a high level of taxonomical identification of the samples a multidisciplinary approach has been used. The different fields of investigation and kind of source of information allow a comparison of different trends that can lead to a single solid conclusion, reducing the aberration possible in a mono-thematic approach. The open structure of the surveys and all the collateral information obtained, with every step forward a more detailed analysis beyond the final score, allow the operator to get also an idea on the single issues that may threat or alter the analysed environment, and propose resolutions.

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Heliographic signalling in *Haploglenius* Burmeister, 1839 (Neuroptera Ascalaphidae)

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ABSTRACT The males of the ascalaphid genus *Haploglenius* are equipped with a movable pronotal flap, covering a white thoracic membrane, whose function remains poorly known. Few recent original observations, conducted on undisturbed specimens in their natural environment, suggest that this structure is part of a complex visual communication system based on intermittently showing the bright, reflecting, thoracic white area on a dark background. This behaviour is probably associated with courtship.

KEY WORDS Animal communication; reflected light; camouflage; Owl-flies.

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On July 23th 2009, during a field survey in Otongachi Forest (Ecuador, Pichincha, La Unión del Toachi) at 850 masl, 0° 18' 49" S, 78° 57' 15" W, the attention of one of the authors (GO) was attracted by a blinking "bright white spot" located into a small hole (about 15 cm deep) among tree roots. The frequency of the signal reminded the flash displays of a firefly, starting whenever the shadow of the observer clouded the midday light. At a closer look, the source was revealed to be an immobile and perfectly hidden adult Ascalaphidae rhythmically lifting up and lowering a flap-like structure on the pronotum with a shining white inner face. The specimen was immediately collected and later identified as a male of *Haploglenius latoreticulatus* van der Weele, [1909] (Fig. 1); it is now preserved in the R.A. Pantaleoni collection.

Furthermore, during the editing of the present work, on March 4th 2014 and again during the day, Giovanni Onore had the opportunity to witness the behaviour in another male ascalaphid in the same locality and just a few hundred meters from the previous observation site (Fig. 3); the owl-fly was displaying inside a thick tuft of Poaceae. On March 23th 2014 a further specimen was observed at Otongachi station, in this occasion attracted to light (Figs. 4, 5). Both specimens have been collected and photographed and, in spite they still require to be appropriately studied, it is possible to identify them as two males belonging to the same species, *H. latoreticulatus*.

The presence of a pronotal flap in South American male owl-flies of subfamily Haplogleniinae has been formerly observed by van der Weele (1909) and Penny (1981), moreover Tjeder (1992) notably reported a similar structure in a still undetermined African genus belonging to subfamily


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Figures 1–3. *Haploglenius latoreticulatus* van der Weele, [1909](Otongachi, Ecuador), views of the prothoracic signaling lobe. Figure 1: habitus of a male specimen with lifted up pronotal flap, showing the bright white marking. Figure 2: detail of the pronotal flap and of the underlying reflecting white membrane. Figure 3: live specimen performing heliographic signals; photos courtesy: A. Barragan.

Ascalaphinae. The only observation about its function in a living specimen was compiled by Eisner & Adams (1975). This striking morphological feature remains poorly investigated, indeed neither an accurate morphological description of the flap (or "dorsocaudal lobe of the pronotum"according to Penny) nor a comparison of the same among different taxa has been published. The structure is certainly present in the males of two closely related South American genera of the tribe Haplogleniini: *Haploglenius* Burmeister, 1839 and *Ascalobyas* Penny, 1981. However, as the flap is often not mentioned in the descriptions of these taxa, it is unclear if it lacks in certain species or if it has been simply omitted.

The flap is a lobe resting on the pronotum when inactive, and rising up when excited (Figs. 2, 3, 4). Its superior/exterior face is homochrome with pronotum, while the inferior/inner face is bright white like the pronotal membrane, with which it is in contact, therefore displaying a rounded white spot when lifted (Figs. 2, 3). The only published account regarding the flap mobility in an alive specimen was done by Thomas Eisner who had a opportunity to observe the response to manipulation of a male of *Haploglenius luteus* (Walker, 1853) attracted to light at the Smithsonian Tropical Research Station, Barro Colorado Island, Canal Zone, on November 17th 1968. Every time the male owl-fly was touched or grabbed, it immediately showed the bright marking. Eisner & Adams (1975) speculated "that this "flashing" behaviour is defensive in function. Whether it merely startles predators or serves also as reinforcement of distastefulness cannot be said, [...].

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Figures 4–5. *Haplogenius latoreticulatus* van der Weele, [1909] (Otongachi, Ecuador), live specimen showing the pronotal flap in resting position. Figure 4: dorso-lateral view. Figure 5: lateral view; photos courtesy: M. Kozánek.

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Figures 6–7. *H. luteus* (Walker, 1853). Figure 6: lateral view of live specimen (Bigal River Biological Reserve, Orellana, Ecuador), the white pronotal membrane is visible under the lobe; photo courtesy: Thierry Garcia. Figure 7: live male specimen from Ecuador with lowered pronotal flap; photo courtesy: Arthur Anker.

The startling function need not be the only, or for that matter primary, function of the flap. Since the device is restricted to one sex, it probably serves also for signalling purposes in courtship."

The observations of Giovanni Onore make clear that the flap and the underlying membrane are comparable to a heliograph as the owl-fly does not emit light but it is able to efficiently signal by reflecting light by means of the white membrane, while the frequency of the signal is regulated by the up-and-down movements of the lobe. Apparently, the blink is associated with courtship and it is very similar to that of fireflies. The illumination may play a decisive role in stimulating the beginning of the behaviour, since it is probably triggered when the light environment ensures the visibility of the signal and at the same time the crypsis of the displayer. Notably, the species equipped with the pronotal lobe are characterized by a cryptic coloration (Figs. 6, 7).

The displaying behaviour observed in male *Haplogenius* is surprising, as there was no clue permitting to presume a similar communication mode. The "heliographic" structure is very peculiar and such a wilful and controlled use of the reflected light is rare if not unique in nature. The greater affinities appear to be with the cromatophores of cephalopods (Mäthger et al., 2009). A main future question to solve about the owl-fly signal is if the flap is able to reflect polarized or ultraviolet light as well known, e. g., in in butterflies of the genus *Heliconius* Kluk, 1780 (Sweeney et al., 2003; Bybee et al. 2012). Similarly, it would be very interesting to understand the role of the displaying system in courtship and its analogies with, e. g., that of fireflies (Lewis & Cratsley, 2008). Unfortunately, the brief period of the day in which the suitable light conditions stimulating the behaviour occur and the elusiveness of these owl-flies make difficult to observe the display in the field.

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